JUN 6 1928

INSTRUMENTS

INDUSTRIAL — SCIENTIFIC

Devoted to the Instrument Problems of all Industries

Vol. 1. No. 1 Pittsburgh, Pa. January, 1928

IN THIS ISSUE

The Use of the Microscope in Industry
ROBERT G. GUTHRIE, CHICAGO, ILL.

A Résumé of the Magnetic Methods Employed in Studying the Mechanical Properties of Matter.
PROFESSOR S. R. WILLIAMS, AMHERST, MASS.

Sand Tests—What Do They Mean?
A. A. GRUBB, MANSFIELD, OHIO.

Portable Photometer for Measuring Colored Light.
LOUIS E. BARBROW, WASHINGTON, D. C.

Complete Analysis of Gas by Simultaneous Oxidation of Methane, Carbon Monoxide and Hydrogen.
HOFRAT PROFESSOR HANS VON JUEPTNER, VIENNA, AUSTRIA.

Place initials of interested persons in your organization opposite title and call it to their attention.

Instruments *and* Supplies FOR EVERY INDUSTRY

CORRESPONDENCE
INVITED
ILLUSTRATED
LITERATURE
ON REQUEST

Blue Print Dryers
Paragon Blue Print Machines
Revolute Blue Print Machines
Blue Streak Blue Print Machines

Anemometers
Aneroid Barometers
Mercurial Barometers
Rain Gauges
Recording Barometers
Thermometers
Transits and Levels
Drafting Room Tables
Drafting Machines
Plan Filing Cabinets Metal or Wood
Drawing Materials
Drawing Instruments
Industrial Motion Picture Projectors
Photostats and Blue Prints
Blue Print Papers
Brown Print Papers

Transits and Levels Repaired

B.K. ELLIOTT COMPANY

127 Sixth Street
Pittsburgh,
Penna.

734 Prospect Avenue
Cleveland,
Ohio

This Book . . . .

reveals the Amazing Adaptability of MERCOID Controls

for Industrial Purposes

Send for YOUR *Copy*

NO engineer, no technically trained man, is too busy to contribute to development in his particular field or any production phase or operation therein.

Because of this, we are asking the engineering and technical men of American Industry to send for this book and to make a little study of MERCOID Automatic Controls in connection specifically with their control problems.

We are frank to say that it was the technical men of American Industry who awakened us several years ago to the potentialities of this little instrument, and prompted the research, experimentation and development work which has since made MERCOID so successful and so indispensable in almost every manufacturing industry.

MERCOID, years ago, proved its dependability and accuracy in the heating industry. Today—thanks to the Engineering and Technical Executives of American Industry, it is proving just as dependable, just as positive and accurate, and infinitely more invaluable, in the control of temperature, pressure and vacuum for innumerable industrial practices and processes. We feel, therefore, that it is essential that you send for this book. It is free. *Just clip the coupon, fill it in, and send it to us.*

AMERICAN RADIATOR COMPANY

ACCESSORIES DIVISION
816-820 South Michigan Avenue
Chicago, Illinois

American Radiator Co.
Chicago, Ill.

Send me free illustrated literature on MERCOID Controls for Oil Burners.

Name.....
Street.....
City ..... "R"

If you are interested in industrial instruments for measuring, checking or controlling various operations in the industries, you should be a subscriber and reader of the only American Instrument Journal—

INSTRUMENTS

INDUSTRIAL—SCIENTIFIC

a monthly publication devoted to the instrument problems of all industries.

Subscription - - - $2.00 per year

A JOURNAL WORTH READING

A JOURNAL YOU WILL APPRECIATE

Our Guaranteed Distribution of 10,000 copies monthly

is on the rotary plan. 45,000 plants are represented on our mailing list to date. Each issue, 10,000 copies will be sent to subscribers and others. The later will be chosen from our list. If you do not subscribe you will not receive the next issue and every issue contains important instrument information which you should not miss. Two Dollars for a year's subscription guarantees your receiving every issue for one year. Any article appearing in a single issue is well worth the price of the subscription. Mail TWO DOLLARS to-day and have your name placed upon our every issue list of paid subscribers. It will be two dollars well invested.

ARTICLES BY AN EXPERIENCED EDITORIAL STAFF AND COLLABORATORS WITH WIDE EXPERIENCE AND TECHNICAL KNOWLEDGE

INSTRUMENTS PUBLISHING CO.

1117 WOLFENDALE ST. PITTSBURGH, PA.

SEARCHING THE ENTIRE FIELD

of mechanical invention and development, selecting that which is best and casting aside the poor or indifferent is the method of this company in obtaining the supplies and equipment offered for sale.

Dividing all that is accepted into individual departments in charge of engineers and salesmen who not only know the goods but understand their use, that is Colonial Service.

It is at your service. Your inquiries for quotations or information are solicited.

Watch for our coming announcement of an entirely new and different type of Radiation Pyrometer.

COLONIAL SUPPLY COMPANY

MILL, MINE, MACHINISTS RAILWAY OIL AND GAS

ELECTRICAL AND CONTRACTORS SUPPLIES

217 WATER STREET, PITTSBURGH, PA.

Phone COurt 1042

Authorized Distributor All Types Ball Bearings Manufactured under Supervision—Skayef Self-Aligning—Hess-Bright Deep Groove and Thrust Bearings. SKF

MEASURING ∴ ∴ INDICATING ∴ ∴ RECORDING

If it's flow
If it's pressure
If it's temperature,
flue gas analysis, or
indicating an engine

ASK

BACHARACH

- ☐ Pressure Recorders.
- ☐ Gas-Flow Meters.
- ☐ Blast Meters.
- ☐ Manometers.
- ☐ Engine Indicators.
- ☐ Optical Pyrometers
- ☐ Ardometers.
- ☐ Electric CO_2 Meters.
- ☐ Electric CO Meters.

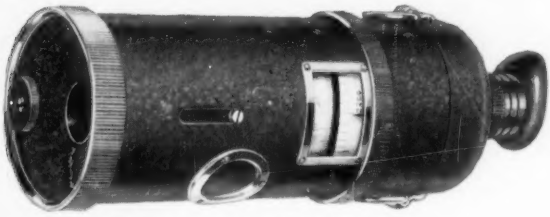
Tear out,
mark
and mail
for description of

NAME
TITLE
COMPANY
ADDRESS

Bacharach
INDUSTRIAL INSTRUMENTS

Bacharach Industrial Instrument Co.
7008 Bennett St. Pittsburgh, Pa.

Pyrometry Simplified



The New Pyro Optical Pyrometer

Pyro Insertion Pyrometer

Entirely self contained. No outside batteries, no accessories. No calculating, no opportunity for mistakes in judgment.

Pyro Radiation Pyrometer

Write for bulletins

Pyro

Pyrometer Instrument Co. 74A Reade St., New York, N. Y.

2376

SPECIAL SERVICE FOR SUBSCRIBERS

SUBSCRIBERS Service Section of INSTRUMENTS is operated to give quickly, reliably and at a minimum expense the following service:

1. **Complete copies of articles covered in the Abstract Section**
2. **Translations of foreign articles covered in the Abstract Section**
3. **Lists of references to books and articles on any instrument, method of testing, measurement, etc.**

INSTRUMENTS makes the entire field of literature on instruments and their application and use available to every subscriber; distance is eliminated, for it will copy the desired information and send it to you. It also assists the busy man by supplying information without any expenditure of his time. The charge for this personal work is merely its cost.

The Subscribers Service Section of INSTRUMENTS does not obtain any profit from the work, but does this to make the information contained in our library and the large libraries with which it has connection available to every subscriber. The rates are as follows:

Photo Print Copies of articles, drawings, etc., 35c per 10x14 sheet plus cost of mailing

Searches, etc., $2.00 an hour

Translation, $10.00 per thousand words for French or German; $15.00 and upwards for other languages

INSTRUMENTS PUBLISHING CO.
1117 WOLFENDALE ST., PITTSBURGH, PA.

RAWSON

ELECTRICAL INSTRUMENT CO.

INCORPORATED

CAMBRIDGE, MASS.

SPECIALISTS IN HIGH SENSITIVITY METERS

MULTIMETER

SINGLE PIVOT

BI-PIVOT

RAWSON METERS

Are Giving General Satisfaction in the Leading Laboratories of America and Abroad

ELECTROSTATIC VOLTMETER

D. C. MULTIMETER, 13 ranges, Reading currents from microamp. to 1 amp. and Voltages from 50 micro volts to 600 volts. Suitable for use with RAWSON THERMO COUPLES IN VACUO on RADIO FREQUENCIES.

A. C or D. C. THERMAL MULTIMETER, 13 Ranges, Reading from 2 milliamps to 1 amp and 60 millivolts to 1000 volts with resistance of 100 ohms per volt. Suitable for use on D. C. or AUDIO FREQUENCIES.

ULTRA SENSITIVE SEMI-SUSPENDED METERS for currents to .02 microamp and 2 microvolts.

ANY single or multirange included in above can be supplied.

ELECTROSTATIC VOLTMETERS, single or multiple range from 0-120 volts to 2500 volts for use on A. C. of Commercial or Audio Frequency. Practically NO LOAD on circuit. IDEAL for use on output voltages on Radio Sets and testing capacity and insulation of small condensers. Also OPEN CIRCUIT VOLTAGES ON B ELIMINATORS.

WATTMETERS single and multirange for use on D. C. or A. C. having POWER FACTORS between Unit and .01

LUSH CABLE TESTERS for general testing and high resistance faults.

McCOLLUM EARTH CURRENT METERS for measurement of Electrolysis in buried structures.

Write for Bulletins

Factory & Engineering Dept.
90-92 Windsor Street
Cambridge, Mass.

Branch: Sales and Service
91 Seventh Avenue
New York City

Watch the Dump

"PRACTICALLY every bit of material that any concern receives is checked in and has an invoice attached," says R. P. Warner, writing in *System*. "In due time it has to be paid for—hence practically all that later goes out by way of the ash heap, or dump barrel, has originally cost the business money. And of course it is a simple truth that the closer this waste can be watched, and the more it can be reduced by use in manufacturing, or by the sale of by-products, the more we can increase profits."

All over America today there are opportunities to improve or refine products, to gain the advantage over competition by the application of the latest development in science. In every case instruments are necessary.

INSTRUMENTS PUBLISHING CO.

80% reduction in motor trouble due to sudden insulation failure at a cost of

86c per motor per year

That is what a "2 in 1" Megohmer accomplished for the Kewanee Boiler Company according to a Nielsen Certified Performance Survey.

Copies of this survey will be mailed upon request.

"2 in 1" MEGOHMER

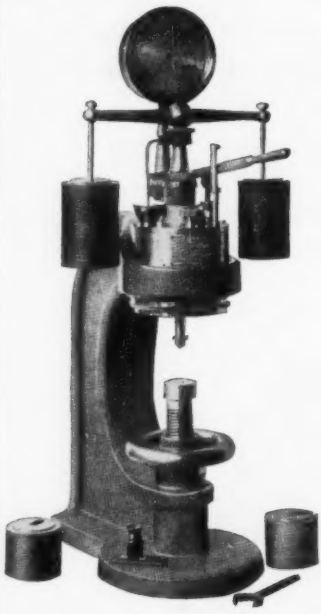
Used by leaders in various industries such as

United States Steel Corp.
General Motors Corp.
Lehigh Portland Cement Co.
American Gas & Electric Co.
New York Central Railroad
National Aniline & Chemical Co.
General Electric Co.
National Biscuit Co.
International Paper Co.
United States Rubber Co.
etc.

Send for Bulletin 162 containing a full description of the "2 in 1" Megohmer

HERMAN H. STICHT & CO.

21 PARK ROW NEW YORK, N. Y.



Brinell Testing Machines

Hand and Power Operated

Brinell Microscopes, Micrometers and Depth Gauges to measure ball test indentations.

Pittsburgh Instrument & Machine Co.

1026 Reedsdale St. Pittsburgh, Pa.

Manufacturers of

BRINELL MACHINES, SHEET METAL TESTERS, SURVEYING INSTRUMENTS and SPECIAL APPLIANCES

ADVERTISING can be educational by telling of new instruments and of new uses of old instruments and by showing how they aid and serve.

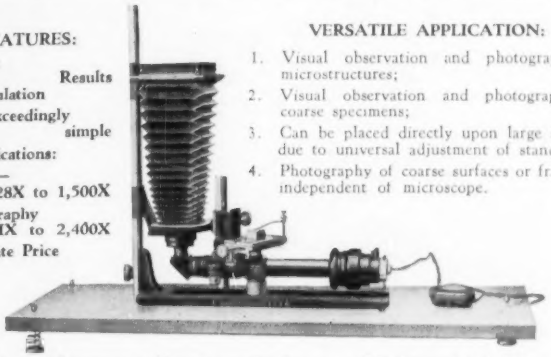
TO apply scientific advertising one must recognize the fact that advertisements are salesmen. One must compare them, one by one, on a salesman's basis, and hold them responsible for cost and result.

LEITZ METALLURSCOPE

Model "MC"—A Metal Microscope with Camera

FEATURES:

Perfect Results
Manipulation exceedingly simple
Magnifications:
Visual— 28X to 1,500X
Photography IX to 2,400X
Moderate Price



VERSATILE APPLICATION:

1. Visual observation and photography of microstructures;
2. Visual observation and photography of coarse specimens;
3. Can be placed directly upon large objects, due to universal adjustment of stand;
4. Photography of coarse surfaces or fractures, independent of microscope.

To make the Microscope still more popular for use in Metallographic Laboratories and to yield to the many wishes expressed for a complete Metal Microscope with Camera for Routine Investigations at moderate price, we offer

THE LEITZ METALLURSCOPE "MC"

Note: For Research Investigations the Leitz Metallograph will, of course, retain its preferred place.

Write for Catalog No. 1114 (II)

E. LEITZ, INC. **60 East Tenth Street, New York, N. Y.**

AGENTS: Pacific Coast States: Spindler & Sauppe, Offices at San Francisco and Los Angeles, Calif. Canada: The J. F. Hartz Co. Ltd., Toronto 2, Canada. Philippine Islands: Botica de Santa Cruz, Manila, P. I. Cuba: Antiga & Co., Havana, Cuba.

When in need of

CONTROLS, THERMOSTATS, ELECTRIC HEATING UNITS, OIL PRE-HEATERS, PLATTENS,

Storage and circulation type electric water heaters for homes and industry. Special electric heat applications for performance to the entire satisfaction of the user . . .

Write Us!

THE AUTOMATIC ELECTRIC HEATER CO.

1505 Race St., PHILADELPHIA, PA.

Over 50,000 installations in the United States and foreign countries will vouch for the quality of our products.

What Instrument Do You Want to Buy?

If you do not see listed in the Advertising pages or in the Buyers' Guide the instruments you wish to purchase . . . .

The Publishers of this journal

would be pleased to forward your request to the manufacturer of the instrument.

THIS

PAGE

RESERVED

Type P-30

Hoyt Switchboard Meters

The HOYT P-30 Meter is representative of the Hoyt Line of Switchboard instruments in all sizes from 2¼ to 8" diameter. All have hand-calibrated scales—good damping, carefully built movements.

Voltmeters—Ammeters—A.C. and D.C.

Pin this advertisement to your letterhead and mail it to us for catalog "HOYT SWITCHBOARD METERS."

HOYT ELECTRICAL INSTRUMENT WORKS
BURTON-ROGERS CO.
Sole Selling Agents
BOSTON MASSACHUSETTS

YOUR BUSINESS is better each day, or worse than the preceding one. One or the other depends on how much real honest-to-goodness action you are using to reach the condition most desired by Better Business.

ADVERTISE NOW—YOU'LL GET YOUR SHARE OF THE BUSINESS AND MORE.

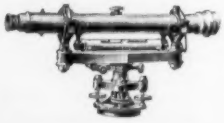
You can't hope to enjoy the harvest without first sowing the seed. You can't expect to pluck the fruits from effort if that effort is not displayed. There is no time like the present—especially if the other fellow is inclined to wait.

ADVERTISE NOW—A FEW JUMPS AHEAD OF THE FELLOW WHO IS INCLINED TO WAIT.

Time lost can never be regained. Putting off YOUR ADVERTISING until tomorrow means a loss of business during the period that could be used to make TODAY A BRIGHTER AND BETTER DAY.

ADVERTISE NOW—MAKE EVERY DAY A BRIGHTER AND BETTER DAY.

Portland Meters and Counters
For Measuring and Counting
Remarkable Accuracy and Endurance
ADDE & COMPANY, Portland, Maine



"FENNEL"
LEVELS, TRANSITS & TACHEOMETERS
are Surveying Instruments of highest Precision
Write for Catalogues to
OTTO FENNEL SONS, Kassel, 85, Germany

THIS publication is copyrighted. Permission will be granted for reprints from INSTRUMENTS on condition that the full title of the article, name of author, page reference, and date of publication are given.

It is hoped that all who are interested in the use of instruments will assist the periodical to achieve its purpose by contributing original papers, notes, etc., dealing with the particular subjects which engage their attention. Authors alone are responsible for statements made and opinions expressed in their respective articles.

An author is entitled to 25 copies of the issue of INSTRUMENTS containing his article.

Rate of subscription throughout the United States of America $2.00 per year; $5.00 elsewhere, payable in advance. Send subscriptions to Circulation Department, Instruments Publishing Company, 1117 Wolfendale Street, N. S., Pittsburgh, Pa.

INSTRUMENTS PUBLISHING CO.

INSTRUMENTS

INDUSTRIAL — SCIENTIFIC

Published Monthly by

INSTRUMENTS PUBLISHING CO.

1117 Wolfendale Street · Pittsburgh, Pa.

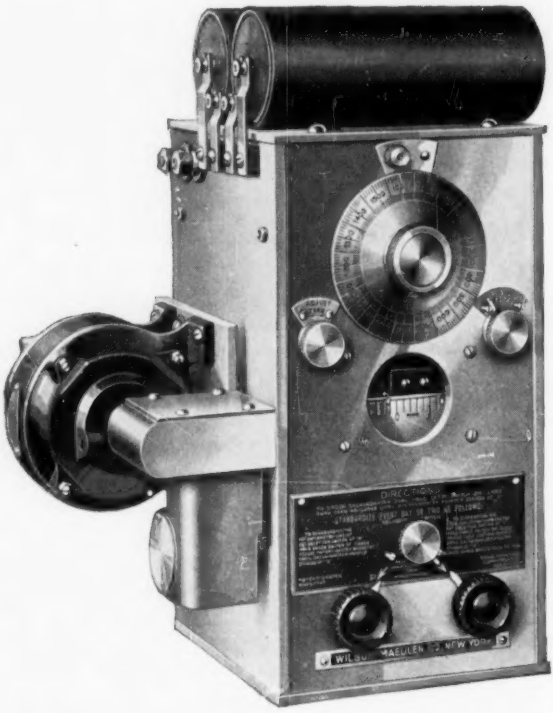
George L. Ray, President Richard Rimbach, V. P. & Treas.

Vol. 1. No. 1. PITTSBURGH, PA. January 1928

TABLE OF CONTENTS

	PAGE
Editorial	1
The Use of the Microscope in Industry—Robt. G. Guthrie	5
A Résumé of the Magnetic Methods Employed in Studying the Mechanical Properties of Matter—Dr. S. R. Williams	29
Sand Tests—What Do They Mean?—A. A. Grubb	39
Portable Photometer for Measuring Colored Light—Louis E. Barbrow	51
Complete Analysis of Gas by Simultaneous Oxidation of Methane, Carbon Monoxide and Hydrogen—Hofrat Prof. Hans von Jueptner	55
Information Section	58
New Instrument Section:	
Wilson-Maeulen Open Scale Recorder	59
The Emley Plasticimeter	60
The Cambridge Recording Accelerometer	61
Fisher Compression Test Machine	63
Tag-Isom Blending Calculator	64
Current Literature Review	67
Review of Recent Patents	73
Catalogue Library	74
Buyers' Guide	17
Advertisers' Index	19
File Card Section	97-100

Have your stenographer cut out and file the 3 x 5 cards found bound in the back of this issue, listing the principal articles. They will direct you to valuable information to which you may wish to refer in the future.



Thermoelectric Pyrometer or Electric Resistance-Bulb Thermometer for

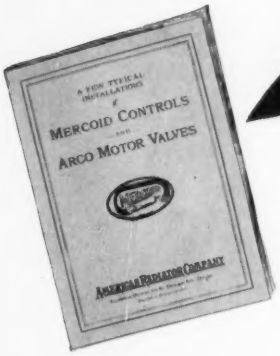
Automatic Temperature Control

1. Strong standard motor located externally.
2. Robust mechanism throughout.
3. Several control units may be operated from a single 1/6 H. P. motor if desired.
4. High order of accuracy.
5. High order of sensitivity.
6. Complete electrical cold-junction compensation for thermocouples.

WILSON-MAEULEN COMPANY INC

381 Concord Avenue New York

This Book . . . .



reveals the Amazing Adaptability of MERCOID Controls

for Industrial Purposes

Send for YOUR *Copy*

NO engineer, no technically trained man, is too busy to contribute to development in his particular field or any production phase or operation therein.

Because of this, we are asking the engineering and technical men of American Industry to send for this book and to make a little study of MERCOID Automatic Controls in connection specifically with their control problems.

We are frank to say that it was the technical men of American Industry who awakened us several years ago to the potentialities of this little instrument, and prompted the research, experimentation and development work which has since made MERCOID so successful and so indispensable in almost every manufacturing industry.

MERCOID, years ago, proved its dependability and accuracy in the heating industry. Today—thanks to the Engineering and Technical Executives of American Industry, it is proving just as dependable, just as positive and accurate, and infinitely more invaluable, in the control of temperature, pressure and vacuum for innumerable industrial practices and processes. We feel, therefore, that it is essential that you send for this book. It is free. *Just clip the coupon, fill it in, and send it to us.*

AMERICAN RADIATOR COMPANY

ACCESSORIES DIVISION

816-820 South Michigan Avenue

Chicago, Illinois

American Radiator Co.
Chicago, Ill.

Send me free illustrated literature on MERCOID Controls for Oil Burners.

Name .....

Street .....

City ..... "R"

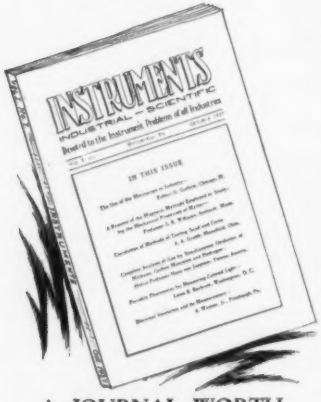
If you are interested in industrial instruments for measuring, checking or controlling various operations in the industries, you should be a subscriber and reader of the only American Instrument Journal—

INSTRUMENTS

INDUSTRIAL—SCIENTIFIC

a monthly publication devoted to the instrument problems of all industries.

Subscription - - - $2.00 per year



A JOURNAL WORTH READING

A JOURNAL YOU WILL APPRECIATE

Our Guaranteed Distribution of 10,000 copies monthly

is on the rotary plan. 45,000 plants are represented on our mailing list to date. Each issue, 10,000 copies will be sent to subscribers and others. The later will be chosen from our list. If you do not subscribe you will not receive the next issue and every issue contains important instrument information which you should not miss. Two Dollars for a year's subscription guarantees your receiving every issue for one year. Any article appearing in a single issue is well worth the price of the subscription. Mail TWO DOLLARS to-day and have your name placed upon our every issue list of paid subscribers. It will be two dollars well invested.

ARTICLES BY AN EXPERIENCED EDITORIAL STAFF AND COLLABORATORS WITH WIDE EXPERIENCE AND TECHNICAL KNOWLEDGE

INSTRUMENTS PUBLISHING CO.

1117 WOLFENDALE ST. PITTSBURGH, PA.

SEARCHING THE ENTIRE FIELD

of mechanical invention and development, selecting that which is best and casting aside the poor or indifferent is the method of this company in obtaining the supplies and equipment offered for sale.

Dividing all that is accepted into individual departments in charge of engineers and salesmen who not only know the goods but understand their use, that is Colonial Service.

It is at your service. Your inquiries for quotations or information are solicited.

Watch for our coming announcement of an entirely new and different type of Radiation Pyrometer.

COLONIAL SUPPLY COMPANY

MILL, MINE, RAILWAY MACHINISTS
OIL AND GAS

ELECTRICAL AND CONTRACTORS SUPPLIES

217 WATER STREET, PITTSBURGH, PA.

Phone COurt 1042

Authorized Distributor All Types Ball Bearings Manufactured under SKF Supervision—Skayef Self-Aligning—Hess-Bright Deep Groove and Thrust Bearings.

MEASURING ∴ ∴ INDICATING ∴ ∴ RECORDING

If it's flow
If it's pressure
If it's temperature, flue gas analysis, or indicating an engine

ASK

BACHARACH

- ☐ Pressure Recorders.
- ☐ Gas-Flow Meters.
- ☐ Blast Meters.
- ☐ Manometers.
- ☐ Engine Indicators.
- ☐ Optical Pyrometers
- ☐ Ardometers.
- ☐ Electric CO_2 Meters.
- ☐ Electric CO Meters.

Tear out, mark and mail for description of

NAME
TITLE
COMPANY
ADDRESS

Bacharach
INDUSTRIAL INSTRUMENTS

Bacharach Industrial Instrument Co.
7008 Bennett St. Pittsburgh, Pa.

Pyrometry Simplified

The New Pyro Optical Pyrometer

Pyro Insertion Pyrometer

Entirely self contained. No outside batteries, no accessories. No calculating, no opportunity for mistakes in judgment.

Pyro Radiation Pyrometer

Write for bulletins

Pyro

Pyrometer Instrument Co. 74A Reade St., New York, N. Y.

2376

SPECIAL SERVICE FOR SUBSCRIBERS

SUBSCRIBERS Service Section of INSTRUMENTS is operated to give quickly, reliably and at a minimum expense the following service:

1. **Complete copies of articles covered in the Abstract Section**
2. **Translations of foreign articles covered in the Abstract Section**
3. **Lists of references to books and articles on any instrument, method of testing, measurement, etc.**

INSTRUMENTS makes the entire field of literature on instruments and their application and use available to every subscriber; distance is eliminated, for it will copy the desired information and send it to you. It also assists the busy man by supplying information without any expenditure of his time. The charge for this personal work is merely its cost.

The Subscribers Service Section of INSTRUMENTS does not obtain any profit from the work, but does this to make the information contained in our library and the large libraries with which it has connection available to every subscriber. The rates are as follows:

Photo Print Copies of articles, drawings, etc., 35c per 10x14 sheet plus cost of mailing

Searches, etc., $2.00 an hour

Translation, $10.00 per thousand words for French or German; $15.00 and upwards for other languages

INSTRUMENTS PUBLISHING CO.
1117 WOLFENDALE ST., PITTSBURGH, PA.

RAWSON

ELECTRICAL INSTRUMENT CO.

INCORPORATED

CAMBRIDGE, MASS.

SPECIALISTS IN HIGH SENSITIVITY METERS

MULTIMETER

SINGLE PIVOT

BI-PIVOT

RAWSON METERS

Are Giving General Satisfaction in the Leading Laboratories of America and Abroad

ELECTROSTATIC VOLTMETER

D. C. MULTIMETER, 13 ranges, Reading currents from microamp. to 1 amp. and Voltages from 50 micro volts to 600 volts. Suitable for use with RAWSON THERMO COUPLES IN VACUO on RADIO FREQUENCIES.

A. C or D. C. THERMAL MULTIMETER, 13 Ranges, Reading from 2 milliamps to 1 amp and 60 millivolts to 1000 volts with resistance of 100 ohms per volt. Suitable for use on D. C. or AUDIO FREQUENCIES.

ULTRA SENSITIVE SEMI-SUSPENDED METERS for currents to .02 microamp and 2 microvolts.

ANY single or multirange included in above can be supplied.

ELECTROSTATIC VOLTMETERS, single or multiple range from 0-120 volts to 2500 volts for use on A. C. of Commercial or Audio Frequency. Practically NO LOAD on circuit. IDEAL for use on output voltages on Radio Sets and testing capacity and insulation of small condensers. Also OPEN CIRCUIT VOLTAGES ON B ELIMINATORS.

WATTMETERS single and multirange for use on D. C. or A. C. having POWER FACTORS between Unit and .01

LUSH CABLE TESTERS for general testing and high resistance faults.

McCOLLUM EARTH CURRENT METERS for measurement of Electrolysis in buried structures.

Write for Bulletins

Factory & Engineering Dept.
90-92 Windsor Street
Cambridge, Mass.

Branch: Sales and Service
91 Seventh Avenue
New York City

Watch the Dump

"PRACTICALLY every bit of material that any concern receives is checked in and has an invoice attached," says R. P. Warner, writing in *System*. "In due time it has to be paid for—hence practically all that later goes out by way of the ash heap, or dump barrel, has originally cost the business money. And of course it is a simple truth that the closer this waste can be watched, and the more it can be reduced by use in manufacturing, or by the sale of by-products, the more we can increase profits."

All over America today there are opportunities to improve or refine products, to gain the advantage over competition by the application of the latest development in science. In every case instruments are necessary.

INSTRUMENTS PUBLISHING CO.

80% reduction in motor trouble due to sudden insulation failure at a cost of

86c per motor per year

That is what a "2 in 1" Megohmer accomplished for the Kewanee Boiler Company according to a Nielsen Certified Performance Survey.

Copies of this survey will be mailed upon request.

"2 in 1" MEGOHMER

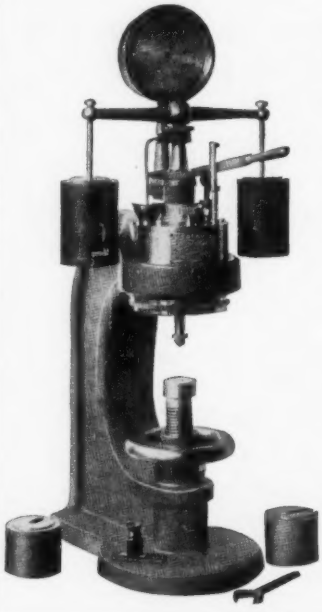
Used by leaders in various industries such as

United States Steel Corp.
General Motors Corp.
Lehigh Portland Cement Co.
American Gas & Electric Co.
New York Central Railroad
National Aniline & Chemical Co.
General Electric Co.
National Biscuit Co.
International Paper Co.
United States Rubber Co.
etc.

Send for Bulletin 162 containing a full description of the "2 in 1" Megohmer

HERMAN H. STICHT & CO.

21 PARK ROW NEW YORK, N. Y.



Brinell Testing Machines

Hand and Power Operated

Brinell Microscopes, Micrometers and Depth Gauges to measure ball test indentations.

Pittsburgh Instrument & Machine Co.

1026 Reedsdale St. Pittsburgh, Pa.

Manufacturers of

BRINELL MACHINES, SHEET METAL TESTERS, SURVEYING INSTRUMENTS and SPECIAL APPLIANCES

ADVERTISING can be educational by telling of new instruments and of new uses of old instruments and by showing how they aid and serve.

TO apply scientific advertising one must recognize the fact that advertisements are salesmen. One must compare them, one by one, on a salesman's basis, and hold them responsible for cost and result.

LEITZ METALLURSCOPE

Model "MC"—A Metal Microscope with Camera

FEATURES:

Perfect Results

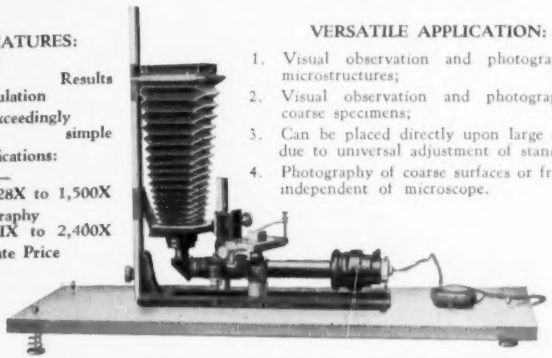
Manipulation exceedingly simple

Magnifications:

Visual— 28X to 1,500X

Photography IX to 2,400X

Moderate Price



VERSATILE APPLICATION:

1. Visual observation and photography of microstructures;
2. Visual observation and photography of coarse specimens;
3. Can be placed directly upon large objects, due to universal adjustment of stand;
4. Photography of coarse surfaces or fractures, independent of microscope.

To make the Microscope still more popular for use in Metallographic Laboratories and to yield to the many wishes expressed for a complete Metal Microscope with Camera for Routine Investigations at moderate price, we offer

THE LEITZ METALLURSCOPE "MC"

Note: For Research Investigations the Leitz Metallograph will, of course, retain its preferred place.

Write for Catalog No. 1114 (II)

E. LEITZ, INC. **60 East Tenth Street, New York, N. Y.**

AGENTS: Pacific Coast States: Spindler & Sauppe, Offices at San Francisco and Los Angeles, Calif. Canada: The J. F. Hartz Co. Ltd., Toronto 2, Canada. Philippine Islands: Botica de Santa Cruz, Manila, P. I. Cuba: Antiga & Co., Havana, Cuba.

When in need of

CONTROLS, THERMOSTATS, ELECTRIC HEATING UNITS, OIL PRE-HEATERS, PLATTENS,

Storage and circulation type electric water heaters for homes and industry. Special electric heat applications for performance to the entire satisfaction of the user . . .

Write Us!

THE AUTOMATIC ELECTRIC HEATER CO.

1505 Race St., PHILADELPHIA, PA.

Over 50,000 installations in the United States and foreign countries will vouch for the quality of our products.

What Instrument Do You Want to Buy?

If you do not see listed in the Advertising pages or in the Buyers' Guide the instruments you wish to purchase . . . .

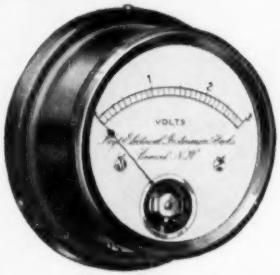
The Publishers of this journal

would be pleased to forward your request to the manufacturer of the instrument.

THIS

PAGE

RESERVED



Type P-30

Hoyt Switchboard Meters

The HOYT P-30 Meter is representative of the Hoyt Line of Switchboard instruments in all sizes from 2¼ to 8" diameter. All have hand-calibrated scales—good damping, carefully built movements.

Voltmeters—Ammeters—A.C. and D.C.

Pin this advertisement to your letterhead and mail it to us for catalog "HOYT SWITCHBOARD METERS."

HOYT ELECTRICAL INSTRUMENT WORKS
BURTON-ROGERS CO.
Sole Selling Agents
BOSTON MASSACHUSETTS

YOUR BUSINESS is better each day, or worse than the preceding one. One or the other depends on how much real honest-to-goodness action you are using to reach the condition most desired by Better Business.

ADVERTISE NOW—YOU'LL GET YOUR SHARE OF THE BUSINESS AND MORE.

You can't hope to enjoy the harvest without first sowing the seed. You can't expect to pluck the fruits from effort if that effort is not displayed. There is no time like the present—especially if the other fellow is inclined to wait.

ADVERTISE NOW—A FEW JUMPS AHEAD OF THE FELLOW WHO IS INCLINED TO WAIT.

Time lost can never be regained. Putting off YOUR ADVERTISING until tomorrow means a loss of business during the period that could be used to make TODAY A BRIGHTER AND BETTER DAY.

ADVERTISE NOW—MAKE EVERY DAY A BRIGHTER AND BETTER DAY.

Portland Meters and Counters
For Measuring and Counting
Remarkable Accuracy and Endurance
ADDE & COMPANY, Portland, Maine

"FENNEL"
LEVELS, TRANSITS & TACHEOMETERS
are Surveying Instruments of highest Precision
Write for Catalogues to
OTTO FENNEL SONS, Kassel, 85, Germany

THIS publication is copyrighted. Permission will be granted for reprints from INSTRUMENTS on condition that the full title of the article, name of author, page reference, and date of publication are given.

It is hoped that all who are interested in the use of instruments will assist the periodical to achieve its purpose by contributing original papers, notes, etc, dealing with the particular subjects which engage their attention. Authors alone are responsible for statements made and opinions expressed in their respective articles.

An author is entitled to 25 copies of the issue of INSTRUMENTS containing his article.

Rate of subscription throughout the United States of America $2.00 per year; $5.00 elsewhere, payable in advance. Send subscriptions to Circulation Department, Instruments Publishing Company, 1117 Wolfendale Street, N. S., Pittsburgh, Pa.

INSTRUMENTS PUBLISHING CO.

INSTRUMENTS

INDUSTRIAL — SCIENTIFIC

Published Monthly by

INSTRUMENTS PUBLISHING CO.

1117 Wolfendale Street · Pittsburgh, Pa.

George L. Ray, President Richard Rimbach, V. P. & Treas.

Vol. 1. No. 1. PITTSBURGH, PA. January 1928

TABLE OF CONTENTS

	PAGE
Editorial	1
The Use of the Microscope in Industry—Robt. G. Guthrie	5
A Résumé of the Magnetic Methods Employed in Studying the Mechanical Properties of Matter—Dr. S. R. Williams	29
Sand Tests—What Do They Mean?—A. A. Grubb	39
Portable Photometer for Measuring Colored Light—Louis E. Barbrow	51
Complete Analysis of Gas by Simultaneous Oxidation of Methane, Carbon Monoxide and Hydrogen—Hofrat Prof. Hans von Jueptner	55
Information Section	58
New Instrument Section:	
Wilson-Maeulen Open Scale Recorder	59
The Emley Plasticimeter	60
The Cambridge Recording Accelerometer	61
Fisher Compression Test Machine	63
Tag-Isom Blending Calculator	64
Current Literature Review	67
Review of Recent Patents	73
Catalogue Library	74
Buyers' Guide	17
Advertisers' Index	19
File Card Section	97-100

Have your stenographer cut out and file the 3 x 5 cards found bound in the back of this issue, listing the principal articles. They will direct you to valuable information to which you may wish to refer in the future.

Thermoelectric Pyrometer or Electric Resistance-Bulb Thermometer for

Automatic Temperature Control

1. Strong standard motor located externally.
2. Robust mechanism throughout.
3. Several control units may be operated from a single 1/6 H. P. motor if desired.
4. High order of accuracy.
5. High order of sensitivity.
6. Complete electrical cold-junction compensation for thermocouples.

WILSON-MAEULEN COMPANY INC

381 Concord Avenue New York

INSTRUMENTS

INDUSTRIAL — SCIENTIFIC

(Copyright, 1928, by Instruments Publishing Company)

Vol. 1. No. 1. JANUARY 1928 Pittsburgh, Pa.

To Our Readers:

IT is obvious that knowledge, even in a relatively narrow field has outgrown the capacity of most individuals. However, encyclopedic we may be by nature or training, we can master only certain fragments of the information which mankind has accumulated. It is conceivable, however, that we shall be able to construct an informational system, which would enable every engineer or scientist to obtain the essential data on a given subject when needed.

There are two important ways in which this diffusion of knowledge can take place. Industry has, where size and resources have permitted it, established its own laboratories and engaged its own staff of scientists and technicians. Or, it has secured this knowledge through the medium of books or other publications.

This latter is of importance for two reasons, first, because every company cannot maintain its own laboratory and staff of scientists and engineers; secondly, that a wide diffusion of knowledge is constantly necessary so as to avoid duplication of research and assure to industry as a whole the benefits of the latest and best scientific knowledge.

In presenting "INSTRUMENTS—Industrial and Scientific" we feel that we are rendering a distinctly valuable service by disseminating information on the uses of instruments in the industries. Devoted exclusively to instruments, the journal fills a long felt need, for this is the first time that instruments for use in all industries will be covered by one publication. Our purpose is to act as a clearing house for vital information and as a medium for the exchange of ideas on this subject.

Information on instruments has heretofore been scattered in many periodicals, and has been given piecemeal to fit this or that trade or process. Within the plants throughout the country are perhaps hundreds of instruments, which are known only to the men in a single industry. These instruments work well, serving a purpose better than any other known equipment, yet the ideas have not traveled beyond one industry.

"INSTRUMENTS—Industrial and Scientific" will undertake to assemble data on instruments and the results of their application to industrial and scientific problems, preserving the information and rendering it accessible to posterity. The editors will comb the world's literature for all

the available information. To make the editorial content of the publication authoritative, and of practical value to its readers, we have in addition to the editorial staff, secured a number of collaborators in the various industries and sciences.

There is another reason why this journal will be invaluable, namely, it will eliminate the lingual difficulty. In the past our reading of scientific literature has been usually restricted by our knowledge of foreign languages. In "INSTRUMENTS—Industrial and Scientific" articles regarding the achievement of foreign workers in the instrument field will be translated.

The scope and importance of the work will require the co-operation of all who desire that this medium of information increase and continue. The editor, therefore, asks engineering and scientific organizations, engineers, scientists and individuals, indeed of all who desire this work to continue and increase, to join with the men whose names are listed in support of this the only American trade journal, which is for those interested in keeping abreast with the latest developments on instruments

———::———

Co-operation

CO-OPERATION is necessary for success and we therefore ask your co-operation to make INSTRUMENTS successful in what we have set out to do—place at your command all the available instrument information in the form best suited to your needs.

We will call your attention to some of the special features in the mechanical set-up of the magazine which will show you how we intend to co-operate with you:

1. The feature articles will be listed on the front cover.

2. The feature articles will also be listed in the table of contents and in addition to this will be placed on file cards ready for filing. As you will see by referring to these cards in the back of the book, each article is printed on a stiff paper, which in addition contains the author's name, the date of the issue, the volume and number of the issue and the pages on which the article appears. Further, an abstract of the article will also be placed on this card.

3. The original articles will always begin on the top of the right hand page. This will permit removing any article in the journal without destroying the previous or following article.

4. Every effort will be made to cover each new development in the instrument field in the New Instrument Section. Again each new development will begin on the right hand page the same as the original articles.

5. The Information Section, Review of Current Literature and the Patent Review will be printed on only one side of the page, carrying

an advertisement on opposite side. This will permit cutting out such material without destroying other information which you also may desire to file.

6. The Catalog Library, Buyer's Guide, and Advertising will contain valuable information.

A number of companies have co-operated with us to make this, the first issue, possible. Their continued support will naturally depend upon you. They have made an investment which consists of the purchase of space in this journal to transmit their sales message to you. If you approach these companies or any other companies in regard to information on anything appearing in INSTRUMENTS they would like to know where you saw the information. Therefore when writing to companies mention INSTRUMENTS as you are in that way co-operating with the company and with INSTRUMENTS.

Summing up we are anxious to co-operate with the readers and the manufacturers by being of the greatest possible service. You can assist us by offering us your comments and criticisms—the manufacturer by placing at our disposal such information as will be of interest to our readers, and supporting our efforts by advertising in INSTRUMENTS.

The co-operation between the instrument companies, the readers of INSTRUMENTS and INSTRUMENTS will be to the mutual benefit of all.

———::———

Who Did It?

"Without tools he is nothing,
With tools he is all."
CARLYLE, *"Sartor Resartus"*

EACH stage of man's progress is marked by an improvement in his tools. Each tool designed today is calculated to save labor and increase production. Instruments are one of the types of tools which are daily becoming more and more invaluable.

Little is known today by the general public, as well as by the scientists and engineers, as to who the greatest instrument builders were, and less is known of their lives and work. History takes good care of the soldier, the statesman, the author, the artist, but what is known of Watt, Ampere, Torricelli, Fahrenheit, etc., the men who made possible the instruments which exist today, and which are used daily with little thought of their origin.

Historical collections of the peaceful arts of science and engineering are a means of teaching the enormous influence, the outstanding technical achievements have had on the development of civilization.

Beginning with the February issue of INSTRUMENTS a new section will be started in the journal. This section will each month give the life history of some scientist or engineer, who was active in the origin or development of instruments.

The Microscope

THE microscope is not only of importance for the examination of iron and steel as is treated in one of the following articles but has also found very extensive use for the investigation of non-ferrous materials. This instrument has also been used for the examination of a vast number of materials, for example—paper.

The problem of making a permanent record of the surface texture of paper has been solved by the application of the microscope. Paper is practically opaque and since light passing through it is not sufficient to illuminate its surface, it must get its illumination from above, as is the case with metal surfaces. There exists on the surface of etched metal specimens a high degree of contrast, due to polished crystals and etched surfaces lying between crystals, also differences in constituents of the crystals. The surface of paper is very unlike that of metals. It differs in that there is very little contrast between the fibres and there exists differences in elevation of the constituents of the paper. In fact, the surface of a piece of paper when viewed through a microscope does not at all resemble a surface but looks more like a thick layer of straw shaken up and then loosely matted. It is this difference in surface texture which permits distinguishing between different papers.

———::———

Information Appearing in Subsequent Issues

IN addition to the articles in this issue, there is shown on page 50 a list of the material now in preparation for subsequent issues of INSTRUMENTS. These articles will be of unusual importance and interest to you. INSTRUMENTS' pages will be crammed full of information on the installation, care, maintenance and uses of instruments.

The use of instruments in modern production throughout all industries is increasing each year. It is surprising the number of applications being found for them.

You have now had an opportunity to become familiar with INSTRUMENTS. It is the only publication devoted exclusively to the needs and problems of this important field.

It will bring to you all the important developments in the field of instruments. It will not only discuss your problems but will suggest means for solving them.

No man or organization interested in the use of instruments can afford to miss a single issue.

We urge you to fill out the subscription blank and mail it back to us at once so you may be sure to receive all future issues.

The Use of the Microscope in Industry

*By Robert G. Guthrie, Chicago, Ill.**

THE three types of microscopes most commonly used in industrial work are known as biological, petrographical, and metallurgical microscopes.

The biological miscroscope uses transmitted light for producing the magnified image, the light or illumination passing through the sample or specimen on through the objective lens and ocular respectively to the eye or camera. This type of microscope is used for examining very thin specimens usually mounted between glass plates. It is pictured diagrammatically in Figure 1. It is used by bacteriologists, physicians, chemists, etc.

The petrographical microscope also uses transmitted light, and is used for examining finely ground, very thin transparent or translucent min-

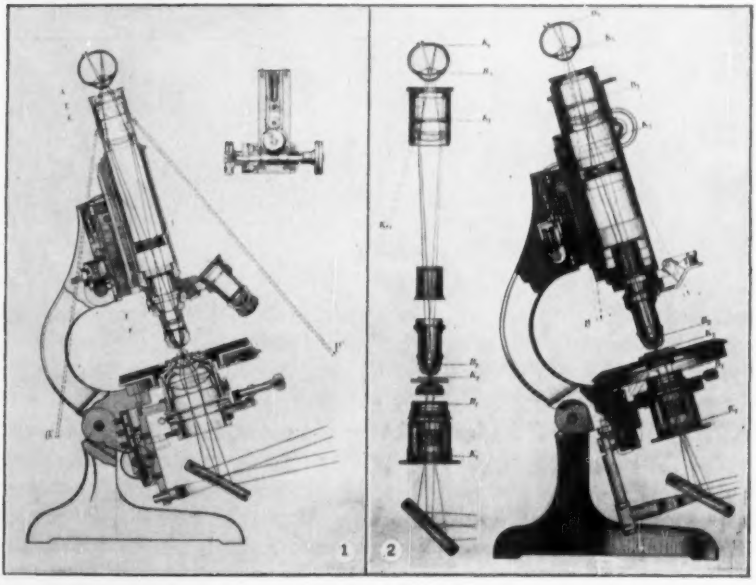


Fig. 1. Fig. 2.

eral or rock specimens. This type is usually equipped with suitable prisms for examining the specimens under polarized light, and is used chiefly for geological work, or for examining glass, etc. Figure 2 is a diagram of it.

*Peoples Gas Light and Coke Company.

The third type of microscope here discussed, and the most important one from a purely industrial point of view, is the metallurgical microscope or micrometallograph. This instrument differs from the others principally in that it is of the reflecting type in which the illumination is communicated to the specimen through the objective lens by means of a vertical illuminator, and the illuminated image of the specimen is reflected back through the objective lens to the ocular and the eye or camera without the light having passed through the specimen. It is obvious that this type is used almost exclusively for the examination of opaque or solid objects. Another convenient feature of the instrument shown diagramatically in Figure 3 is that the stage upon which the speci-

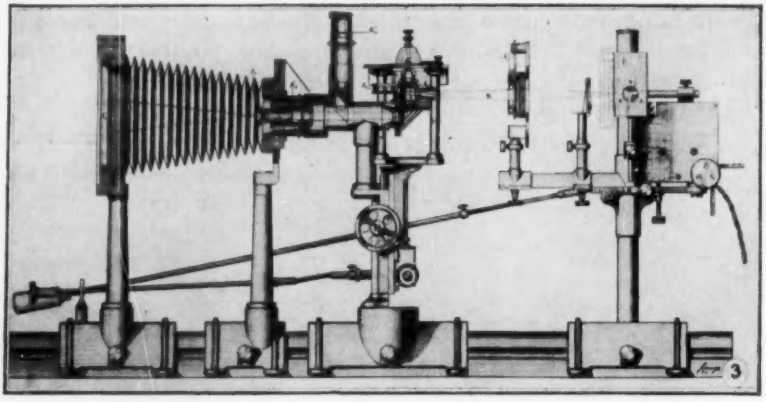


Fig. 3.

men rests is inverted, or in other words is above the objective lens in contradistinction to the other types mentioned in which the stage and specimen are below the objective lens and between the light source and the eye or camera.

The advantages of the inverted type are many, but the chief feature is that the sample has required only one prepared surface, and does not have to be levelled, or embedded in a holding material. In the past five years great strides have been made in improving this type of microscope.

The natural question arising in most people's minds when a microscope is mentioned for analytical work is—What may be discovered by use of the microscope? Why not a chemical analysis? Why not physical tests? Will not a complete chemical analysis augmented by physical tests supply all the information possible on a sample of iron, steel, or other metal? The answer is in the negative, and the reasons for this answer are the basis for this paper.

In the first place the steels of industry are a complicated aggregation of various other metals and metalloids added to iron. Not only do these

substances impart many and varied properties to the iron in the "as made" condition, but they make the iron capable of a wide range of physical properties after mechanical and thermal treatment. The great advantage of a microscope in the study of steels is that microanalysis reveals not only the constituents but their proximity, a thing which is not done either in a chemical or physical test. It has long ago been established that the proximity of the various components in steel, their size, shape, distribution, relation to each other, etc., was all important and very frequently more important than the nature of the constituents themselves or their amounts.

The story from now on is best told by outline and pictures. There are several hundred different types of steel manufactured and sold today, whereas a few years ago (20-50) only a very few kinds existed. These new steels have their uses and for the most part are especially developed to meet specific physical and chemical conditions, and their study is a wonderfully fascinating life's work. Steels as they are made are not always used in that stage but are subjected, besides mechanical operations and work, to heat treatment, and it is by this latter treatment that any physical properties within the limits of a given steel may be developed at will. The microscope is particularly valuable where heat treated steels are considered. No chemical analysis can discover to what sort of heat treatment a given material has been subjected, nor what amount or kind of mechanical work it has received. The microscope, however, in the hands of a capable operator can tell all of this and much more. Typical microscopic analyses will be used in the balance of this paper with the outline:

(1) What is steel?

(2) How can heat treatment make a given steel in one case *soft and ductile,* in another case *hard and brittle,* in a third case *hard and tough,* and in a fourth case, *soft and tough?*

(3) How can the atmosphere surrounding heated steel affect its physical or chemical properties?

(4) What is the relation of a sick or healthy steel to production as well as to its own efficiency?

(5) Why are there so many different kinds of steel on the market today, and why the increasing demand for special steels?

What Is Steel?

The simplest answer is that it is essentially iron and carbon. It is necessary to amplify this statement, however, and say that straight carbon steel is iron with carbon within the limits of .05 percent carbon and about 2 percent carbon. The fact that in practice small amounts of sulphur, silicon, phosphorous, and manganese occur in the steel besides the

iron and carbon need not be considered at this time and for simplicity all steels referred to as steel or plain carbon steel will mean those containing no alloys in appreciable amounts other than carbon.

Let us consider briefly irons and steels, all in the annealed or softest and most ductile condition but of varying carbon content. *Figure* 4 is commercially pure iron of molten origin presumed to contain less than .05 percent carbon.

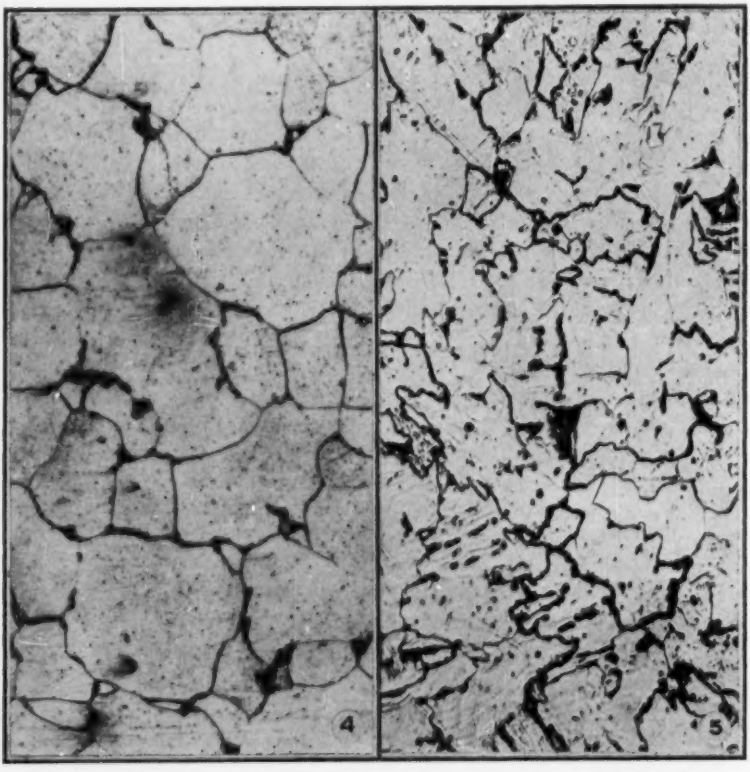


Fig. 4—Magnified 250 Diameters Fig. 5—Magnified 100 Diameters

Figure 5 is so-called wrought iron also of .05 percent or less carbon. This material besides having less carbon than steel is of plastic origin. In other words it is made by puddling or working scraps of iron together in a heated condition just below their melting point, and being plastic at that temperature they stick or weld themselves together. Slag is used to protect the metal from oxidation and the excess slag is largely squeezed out in later operations of rolling, etc. However some slag remains in the finished iron and is rolled out into long fibers, the ends of which are seen in cross-section.

Figure 6 is low carbon steel and as such it is only capable of limited changes in physical properties through heat-treatment. All carbon steels containing less than .85 percent carbon are known as hypoeutectoid steels. The eutectoid is iron with .85 percent carbon and such steels show no excess constituents under the microscope. In other words, .85 percent carbon will just saturate iron to form pearlite. This pearlite is a mixture of iron carbide, called cementite (which has the chemical formula Fe_3C), and iron, called ferrite, arranged in alternate striations or layers and as such is known as lamellar pearlite. The black patches shown in the hypoeutectoid steel in Figure 6 are pearlite but its lamellae are not resolvable at such low powers of the microscope as they vary in number and thickness from a ten thousandth to a two hundred thousandth of an inch.

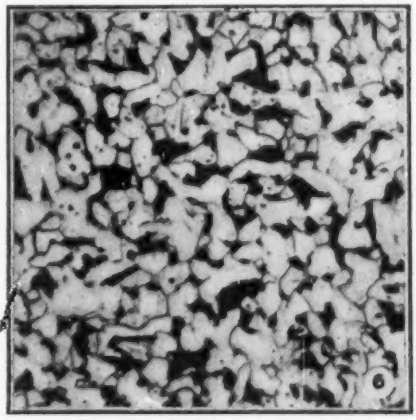


Fig. 6—Magnified 250 Diameters

Figure 7 shows these patches at higher power and now the alternate layers or striations are clearly visible. *Figure* 8 shows the same as Figure 7 but as the photomicrograph was taken with conical illumination the striations or layers appear in relief,—a pseudo three dimensional effect.

Figure 9 shows the eutectoid or .85 percent carbon steel with no excess iron (ferrite). It is taken with flat illumination. *Figure* 10 is the same eutectoid steel taken with conical illumination.

Figure 11 is of the high carbon or hypereutectoid class containing more than .85 percent carbon. In this case the iron is supersaturated with carbon (microscopically) and the excess precipitates out as the steel cools and appears as white lines or areas that are referred to as excess cementite.

Figure 12 is a very high powered micrograph of pearlite.

Summarily then, the low carbon or hypoeutectoid steels show mostly the white or ferrite matrix plus dark patches of pearlite which is a mixture of iron and iron-carbide or cementite. These dark patches contain in themselves .85 percent carbon, and a comparison of Figure 7 with Figure 9 reveals that roughly the fields are alike or of like composition.

Eutectoid steels show a completely pearlitic field with no excess constituent present. See Figure 9.

Hypereutectoid steels show a pearlitic field with white envelopes or areas which are the excess cementite as shown in Figure 11.

The foregoing has considered steels of varying and increasing carbon content all in the annealed or soft state. *Figures* 13 *to* 19 inclusive are of one steel of a low carbon content having two distinct structural conditions within it although its chemical analysis is fairly constant through-

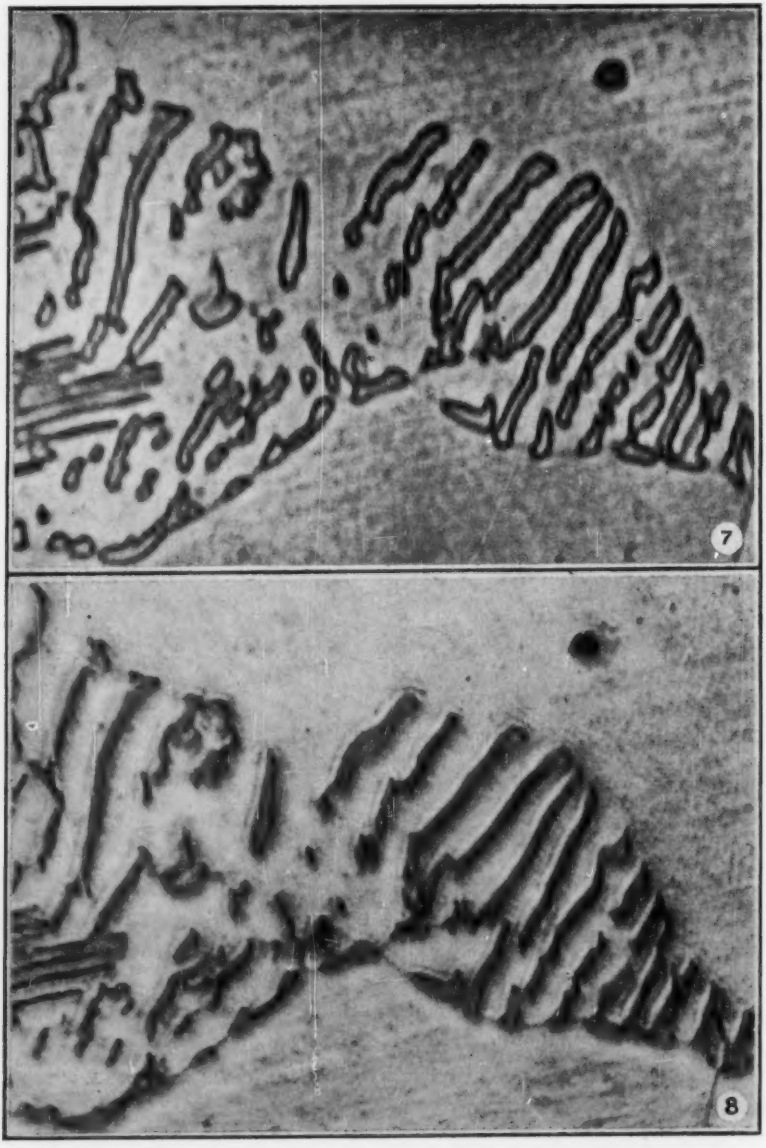
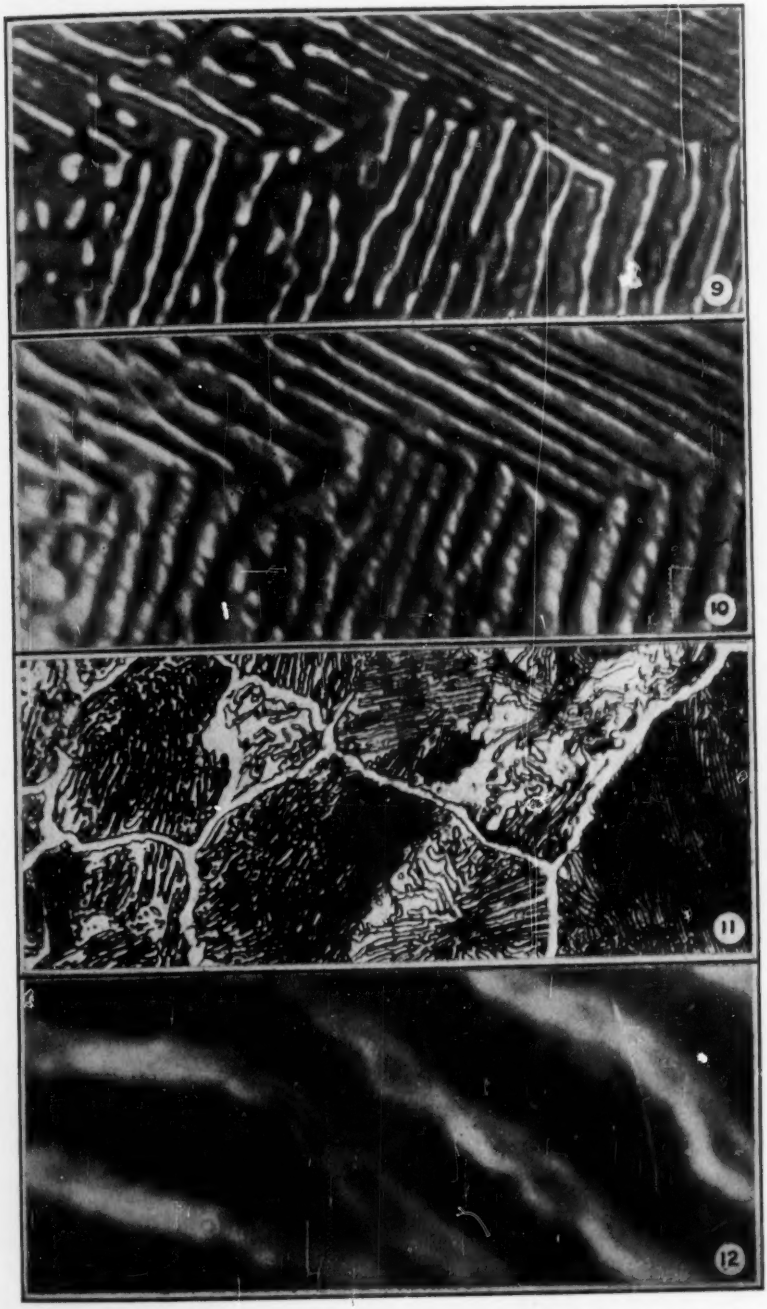


Fig. 7—Magnified 2000 Diameters Fig. 8—Magnified 2000 Diameters



Figs. 9 and 10 Magnified 5200 Diameters. Fig. 11—1000. Fig. 12—12,500

out the cross-section. Live, effervescing, or so-called rimmed steel is made in such a manner that after solidification a core is contained within a rim or case. *Figure* 13 is a macrograph of a rimmed steel billet showing the two structural conditions known as the rim and the core.

Figure 14 is a low power micrograph of the rim and shows the ferritic grains outlined by small particles of something but no pearlitic patches.

Figure 15 shows these small particles to be globules of cementite in the so-called spheroidal condition but no lamellar pearlite is seen.

Figure 16 is a high powered micrograph of the same structure.

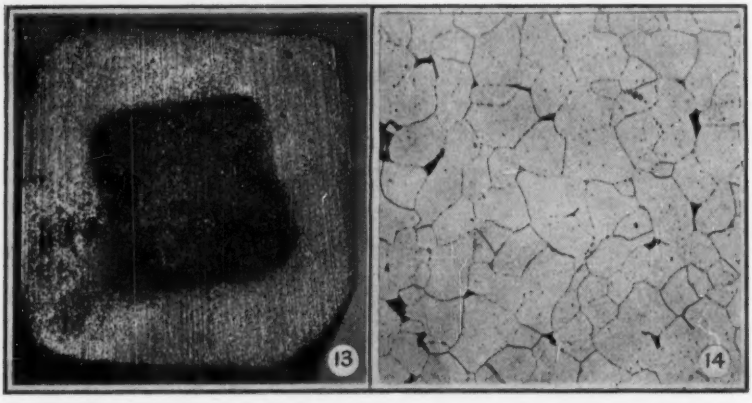


Fig. 13—Normal Size Fig. 14—Magnified 100 Diameters

Figure 17 is a low powered micrograph of the core. *Figure* 18 is higher powered of the same structure and confirms the fact that the carbide is in the pearlitic condition in the core in contradistinction to the spheroidal condition in the case or rim. The greater contamination of the ferrite by the carbide in the pearlitic form causes the core to etch faster than the rim as shown in the macrograph, Figure 13.

Figure 19 shows the junction of the rim and core at low powers.

Heat Treatment

If a steel of given analysis is heated to relatively high temperatures but considerably below its melting point and suddenly cooled by quenching in water or oil an examination with the microscope will show a changed structural condition. The quenched steel will show physical properties much greater in the matter of tensile strength than it did in the "as received" or annealed condition. In this quenched condition, however, it is liable to be brittle and not capable of much deflection before breaking. If, however, the steel after quenching is too hard or

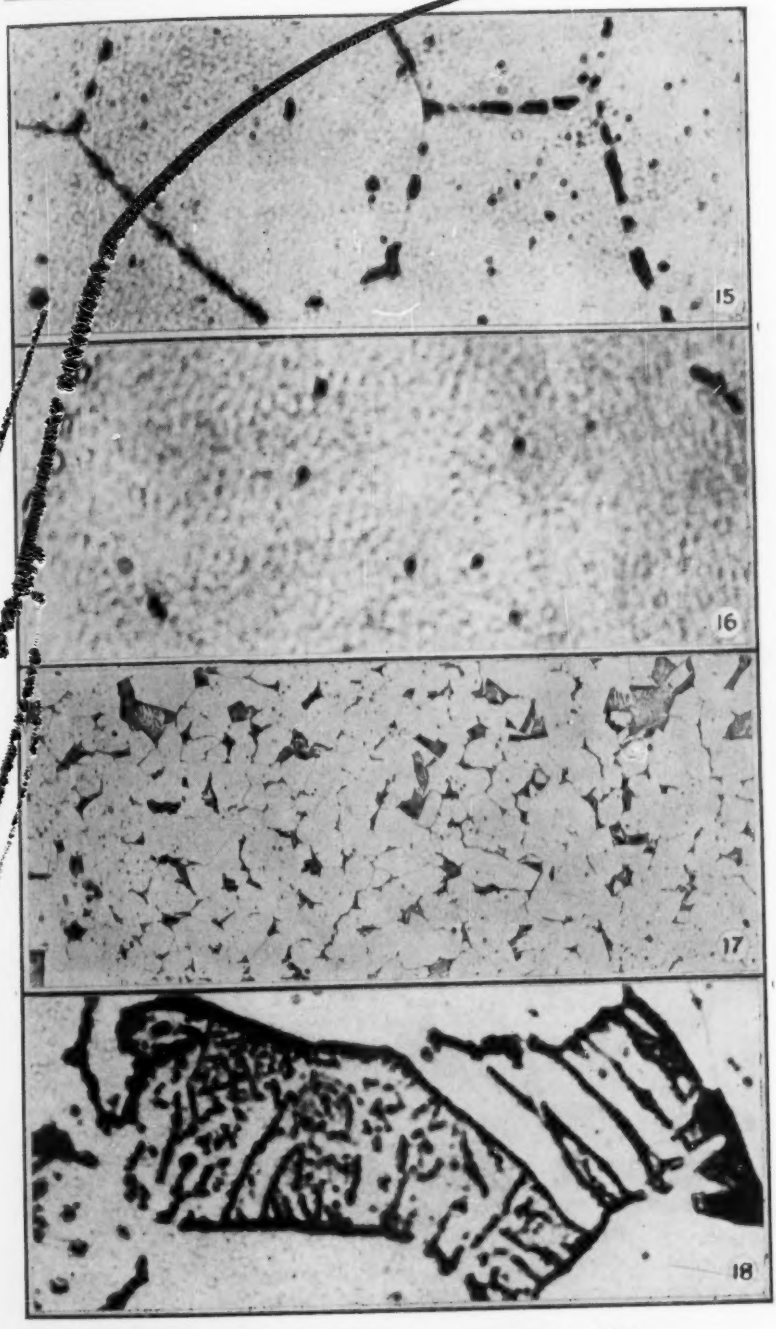


Fig. 15—Magnified 1500 Diameters. Fig. 16—2350.
Fig. 17—100. Fig. 18—1500

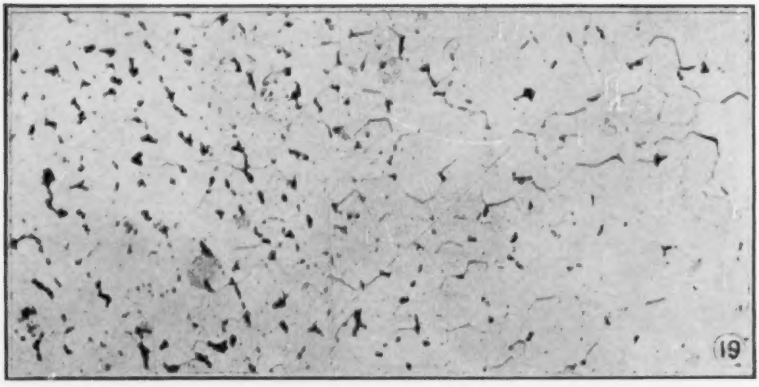


Fig. 19—Magnified 100 Diameters

brittle, this condition may be either slightly or greatly modified by another heating, this time at a lower temperature. This latter operation is known as tempering or drawing and is dependent not only on the temperature but the time as well. Inasmuch as this is a big subject in itself only the influence of quenching and drawing to various temperatures for a given time will be shown in order to illustrate the structural changes which occur within the piece as seen through the microscope, remembering that all the structures represent the same steel with the same chemical analysis.

Fig. 20—Magnified 100 Diameters

Figure 20 is S.A.E. 1020 basic open hearth steel of .20 percent carbon in the untreated or "as received" condition. Compare this with Figure 6.

Figure 21 shows this steel heated to 1650 degrees F. and suddenly cooled by quenching in water. This condition in carbon steels is known as martensite. The steel has been heated above its critical temperature where it will harden, and cooled quickly to retain that condition. The carbide that was in the pearlite of Figure 20 is now said to be in solution or so finely dispersed throughout the mass as to be irresolvable with the microscope but as such exerts an embrittling as well

as hardening effect on the steel. The tensile strength is also appreciably increased.

Figure 22 shows the quenched structure relieved or drawn by reheating to 500 degrees F. The steel is now slightly softer, still quite strong, and more ductile than in Figure 22.

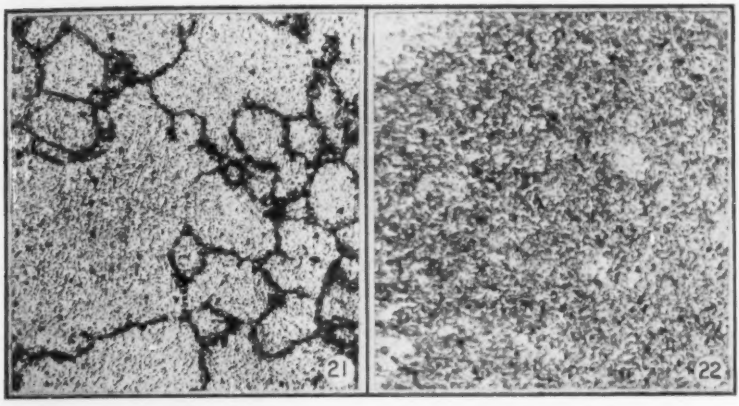


Fig. 21—Magnified 100 Diameters Fig. 22—Magnified 100 Diameters

Figure 23 shows it drawn at 1000 degrees F. and as a consequence is still softer and more ductile but quite tough.

Figure 24 shows it drawn at 1400 degrees F. This is below the critical temperature of this steel and does not allow it to assume the structure

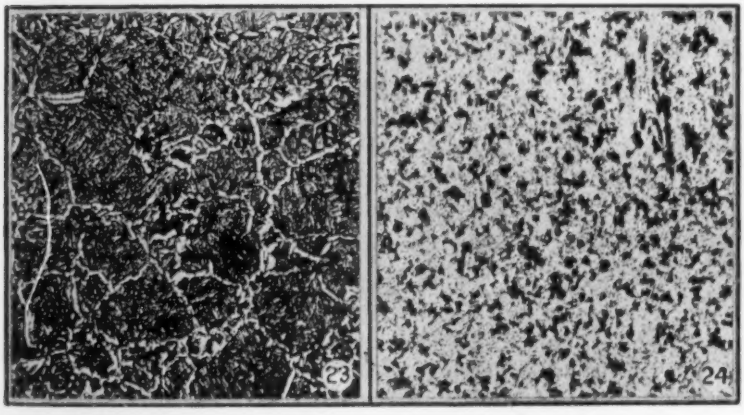
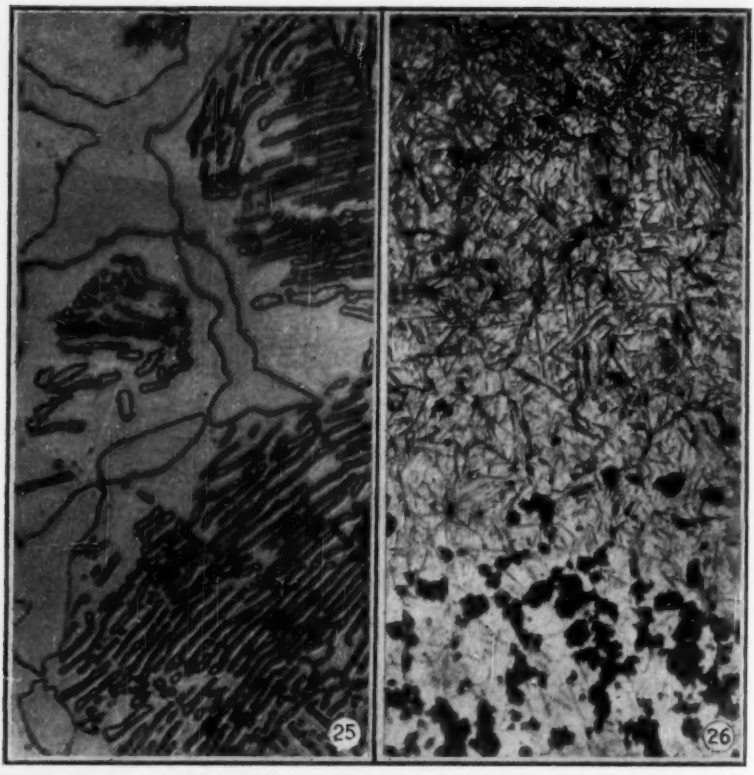


Fig. 23—Magnified 100 Diameters Fig. 24—Magnified 100 Diameters

shown in Figure 20, but it has lost most of the hardness of Figure 21 and is quite ductile but very strong as compared to its "as received" condition. In this as well as in Figure 23 it is said to be tough and strong.



Figs. 25 and 26—Magnified 1000 Diameters

Thus question 2 of the outline is partially answered but there is another general class of structures that should be briefly mentioned and that is steels with the same chemical analysis and the same heat treatment (annealed) may exhibit different structures. The chemical analysis is the same in each case insofar as may be determined. If other elements or compounds exist, which they probably do, they cannot be found by any methods known at present.

Figure 25 shows a field of lamellar pearlite with some excess cementite as well as some excess ferrite, a condition not possible in normal steels. As there should be only one excess constituent present at a time, the condition shown in Figure 25 is called abnormal. As explanation, if the steel is just saturated and shows only pearlite it is presumed to contain about .85 percent carbon. If there is less carbon than this a little excess ferrite will show in proportion to the percent of carbon less than .85 percent, which shows that there is not sufficient carbon to completely saturate the iron. If more than .85 percent carbon is present all the

ferrite will have been satisfied to form pearlite and any excess carbon will exhibit itself as excess carbide or cementite, but in these so called abnormal steels we find both excess constituents. The effect of this is shown when an attempt at heat treatment is made. *Figure* 26 shows the result, a martensitic field but contaminated with troostite, which is the next condition below martensite when martensite is drawn. The order of decomposition of the martensite as obtained in a severe quench is first troostite, which may be obtained with a less severe quench than that necessary to produce martensite or by reheating or tempering martensite; sorbite, which may be obtained with still less rapidity of quench, or by reheating martensite or troostite sufficiently to temper them to sorbite. If the steel is slow cooled from above the critical temperature without quenching the familiar pearlite of annealed steel is produced.

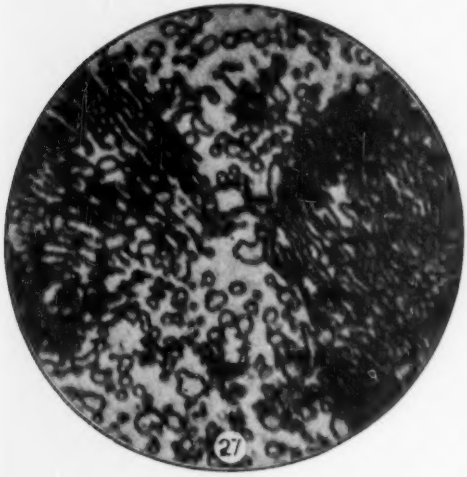
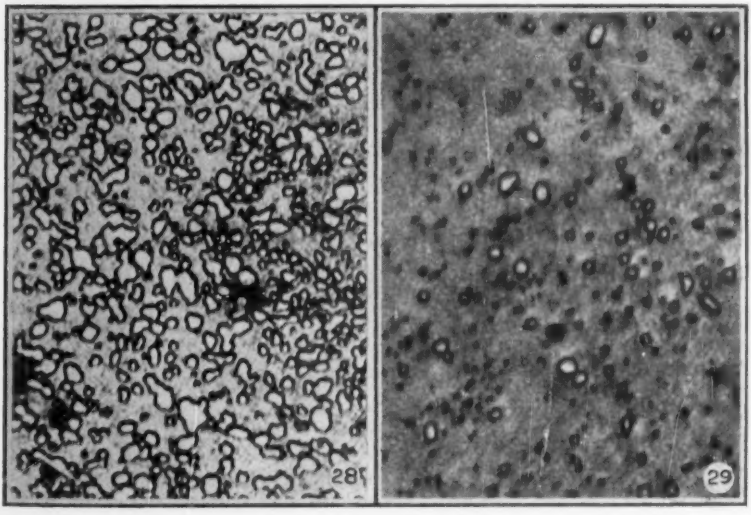
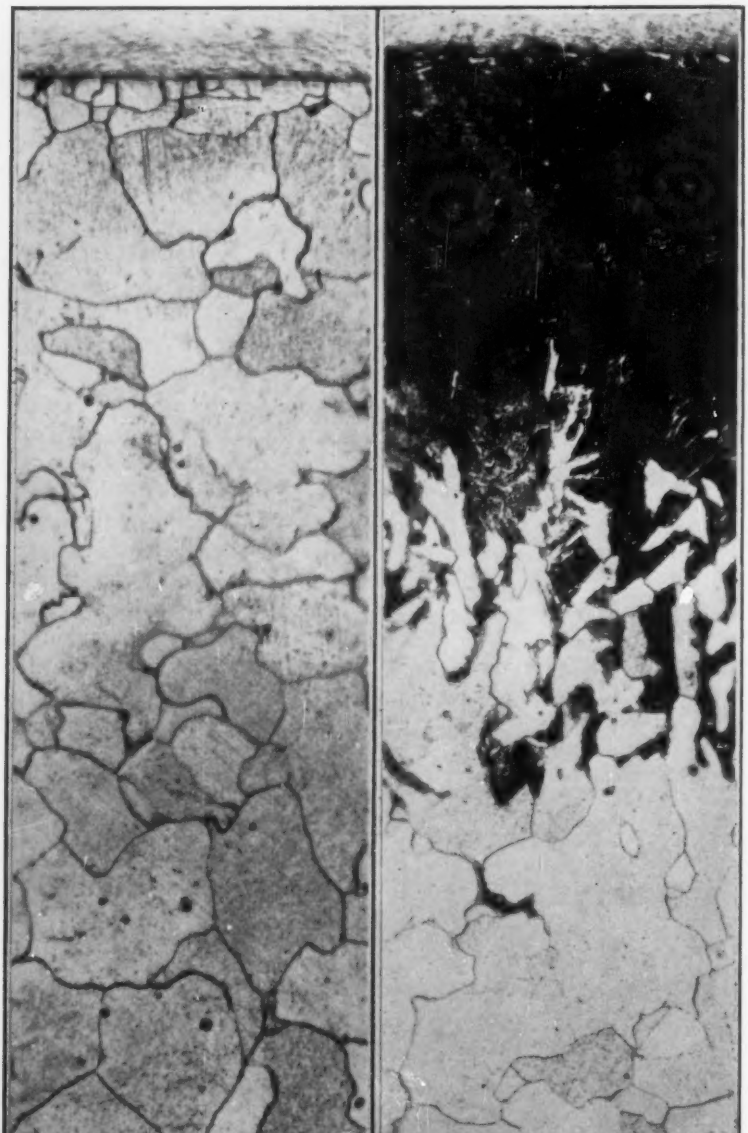


Fig. 27—Magnified 1150 Diameters



Figs. 28 and 29—Magnified 1150 Diameters



Figs. 30 and 31—Magnified 125 Diameters

Therefore, it is apparent that Figure 26 represents a condition of incomplete hardening.

An investigation of this is shown in *Figure* 27 depicting a field partly

Figs. 32 and 33—Magnified 125 Diameters

lamellar and partly spheroidal. Inasmuch as the cementite in the lamellar form is rapidly soluble in the lamellar ferrite when heated to above the critical temperature due to its large surface for its small mass, and

whereas the reverse is true of the spheroids of cementite as their mass is relatively large for their surface, it is obvious, that the same time and temperature conditions that will satisfy the lamellar cementite will not accommodate the spheroids of cementite with equal efficiency.

Fig. 34—Magnified 125 Diameters

Figure 28 shows the cementite in the spheroidal condition as annealed, while *Figure* 29 is the same steel after quenching showing the inefficiency of the time and temperature relation. It shows the characteristic martensite but the cementite spheroids have not been completely diffused or dissolved. This results when the steel is not left above the critical temperature long enough, referred to as insufficient soak.

Effect of Atmosphere on Heated Steel

If steel or iron is heated in an atmosphere of carbonaceous gas its surfaces will absorb carbon. The amount of carbon absorbed and the depth to which it will penetrate depend upon the time, temperature, pressure, composition of the steel, and the analysis of the gas.

This process is known as carburization, or sometimes as case hardening. The resultant product consists of a low carbon core surrounded by a high carbon case which is capable of heat treatment and quite a range of physical properties.

Figure 30 shows this condition in ARMCO iron carburized at 1400 degrees F.

Figure 31 shows the same type of iron carburized at 1500 degrees F.

Figure 32 shows the same type of iron carburized at 1600 degrees F.

Figure 33 shows the same type of iron carburized at 1600 degrees F. Indicates abnormality.

Figure 34 shows the effect of the addition of sulphur to the carburizing gas. The sample was polished and photographed unetched and shows a line of iron sulphide between the case and the core.

If on the other hand steel is heated in an atmosphere containing much oxygen, the oxygen combines with the carbon in the surface of the steel and removes it in the form of gas. This condition is known as decarburization and is subject to a few of the laws of carburization such as time and temperature, the oxygen content of the atmosphere, composition of the steel, etc.

Figure 35 shows high carbon steel decarburized.

Normal and Abnormal Steel

The question of healthy and sick steels relates to those steels we know as normal and abnormal. Undoubtedly someday the so-called abnormal steels will be looked upon as highly desirable for certain purposes, but at present they are the source of much trouble in carburization and subsequent heat treatment. Previously in this paper the subject of normal and abnormal steels was explained and illustrated in Figures 25 to 29 inclusive. However, *Figures* 36 to 43 inclusive may shed a little more light on the subject.

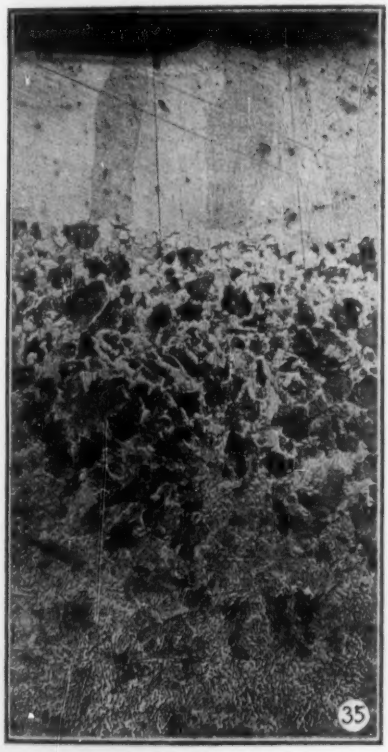


Fig. 35—Magnified 100 Diameters

Consider *Figure* 36 as a normal carburizing steel containing pearlite and one excess constituent, cementite (which appears as white lines). *Figure* 37 is normal steel at higher power.

Figure 38 is carburized abnormal steel and *Figure* 39 is the same at higher power showing clearly the two excess constituents. *Figures* 40 *and* 41 are of abnormal steels also, the latter being an extreme case.

Figure 42 is abnormal steel of another type which after quenching appears as shown in

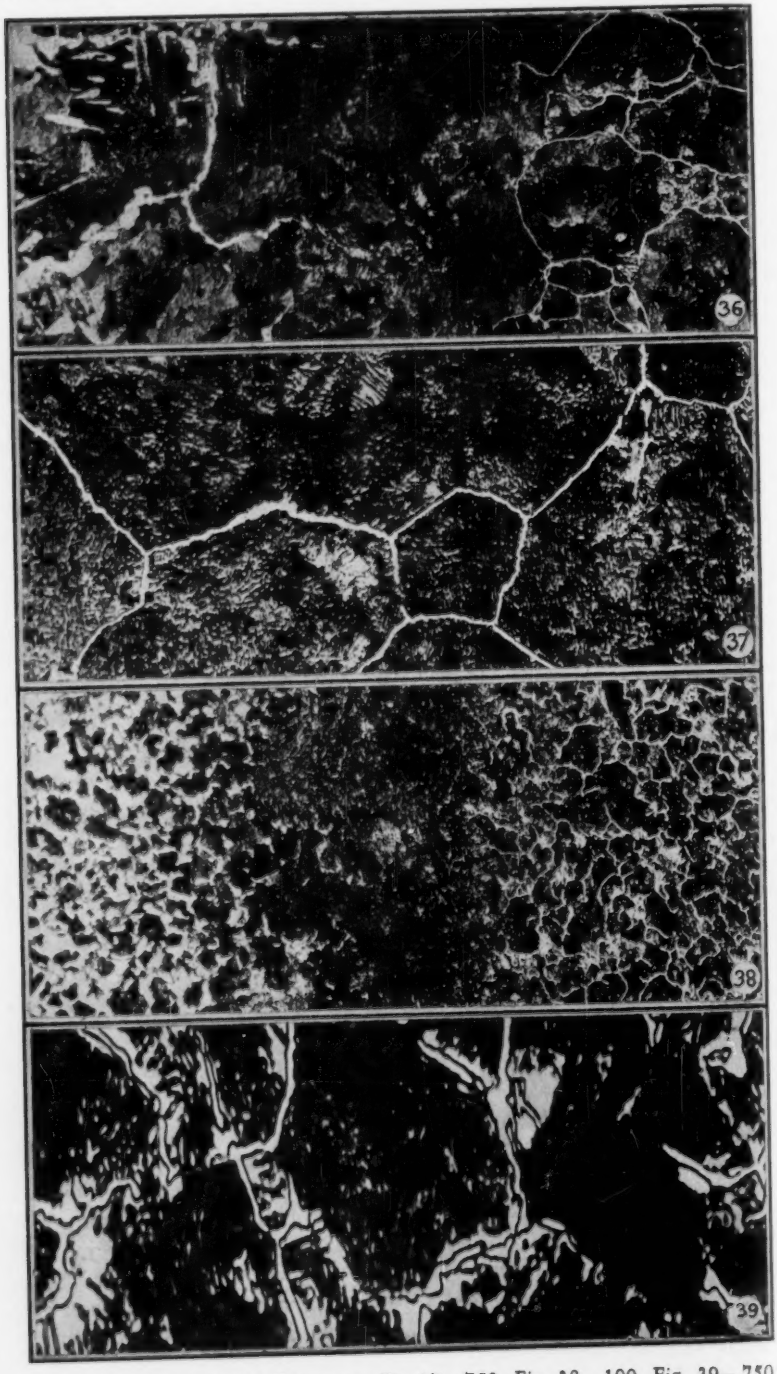


Fig. 36—Magnified 100 Diameters. Fig 37—750. Fig. 38—100. Fig. 39—750

Figs. 40, 41, 42 and 43—Magnified 1000 Diameters

Figure 43. It is when these abnormal steels are quenched or hardened that their real drawback is realized as the abnormal portions do not harden with the homogeneity that the normal portions do under the same conditions, or under conditions that would satisfy normal steels.

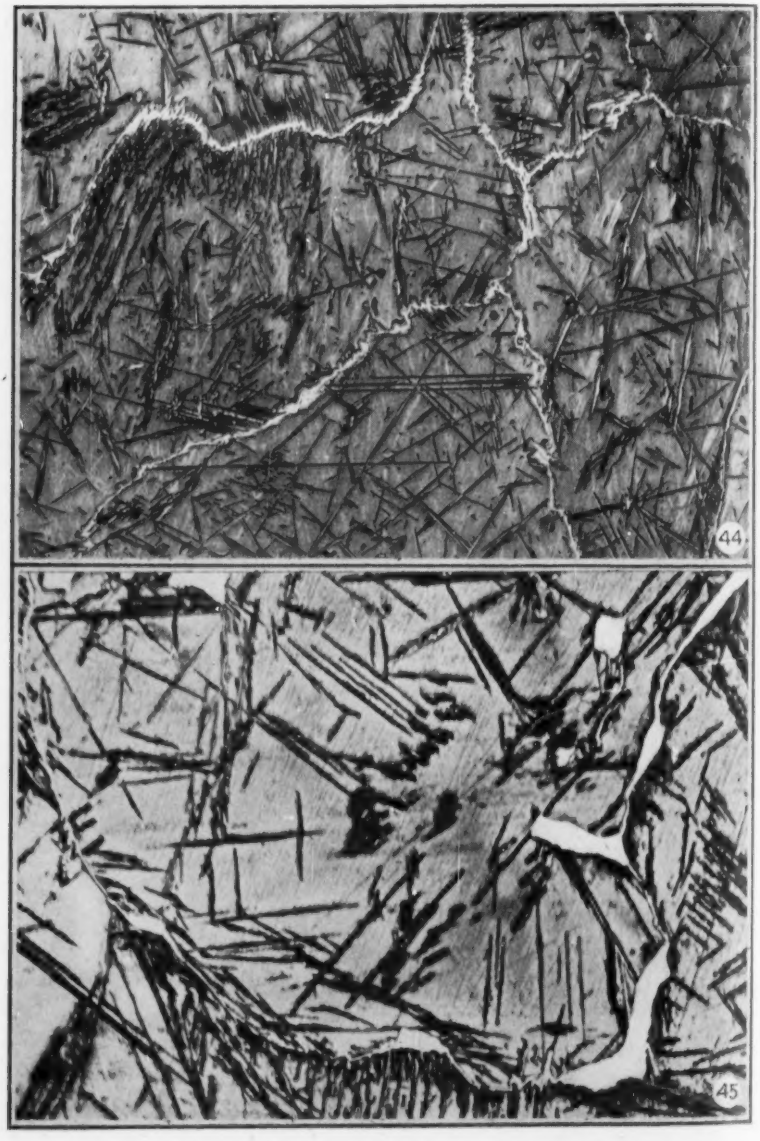


Fig. 44—Magnified 150 Diameters. Fig. 45—1000

Special Steels

Figures 44 to 49 inclusive show two special steels in various conditions of heat treatment.

Figure 44 shows the famous Hadfield's 12 percent manganese steel in the "as cast" condition. This is one of the toughest steels known and although not capable of the hardness of carbon steels it is so tough that it is used for burglar-proof safe doors, cross-overs and switch points on railway tracks, etc. This material is hardened by heating it above its critical temperature and allowing it to cool in air. It never attains the softness of annealed carbon steels, and what little softening that can be effected is obtained by heating to above the critical temperature and

Fig. 46—Magnified 150 Diameters

quenching in water. *Figure 45* is another photomicrograph of this steel as cast.

Figure 46 is the same steel after quenching.

Figure 47 is a higher power of this steel as quenched.

Figure 48 is a micrograph of 18 percent tungsten high speed steel in the hardened condition. This is a tool steel and is used for steel cutting tools. It is much superior to carbon tool steel as its hardened structure is not affected, or tempered, by temperatures attained in high speed cutting, which temperatures would effectively draw back and soften ordinary carbon tool steel. This special steel has made possible the great advances in high speed machining operations.

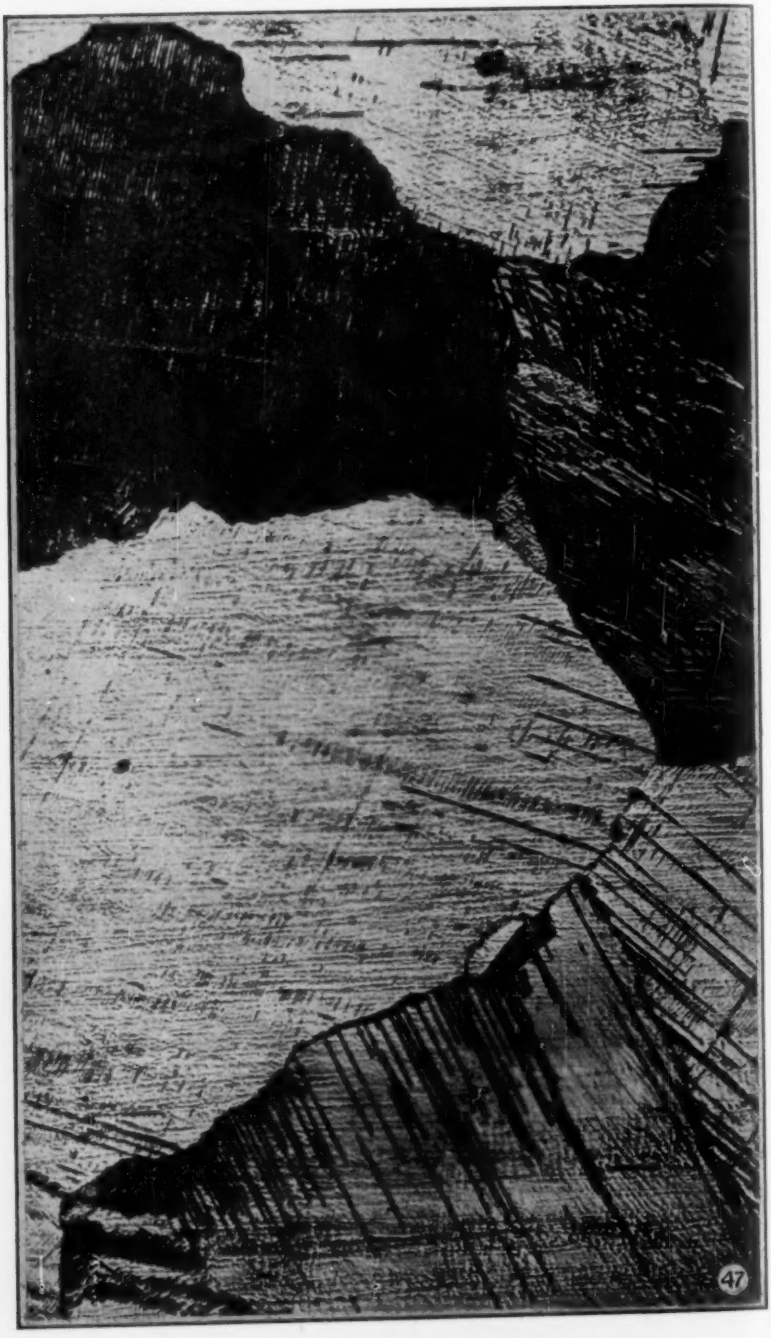


Fig. 47—Magnified 350 Diameters

Like the 12 percent manganese steel, this high speed steel is also air hardening, but in other respects acts much like carbon steel as it is readily machinable when annealed and may be forged, cut, and worked like the straight carbon variety. When hardened, however, it is not affected by temperatures fatal to hardened carbon tool steels.

Figure 49 shows one of the troubles which beset high speed steels at times and is known as banding. These bands of carbide are planes of weakness or brittleness and cannot be removed by heat treatment.

Fig. 48—Magnified 100 Diameters

It is impossible to cover but very incompletely the subject of carbon steel alone in this paper, and such complications as the iron-carbon diagram, allotropic forms of iron, etc., have been purposely left out. Between the carbon steels and the two alloy steels mentioned here there are hundreds of alloy steels that space does not even permit of mentioning. This paper is not meant to be even a partial treatise on steels but rather a compilation of a few remarks upon some of the phases of metallography (the study of steel structures with the microscope) and gives, it is hoped, a small insight into a few of the possibilities of the use of the microscope in industry.

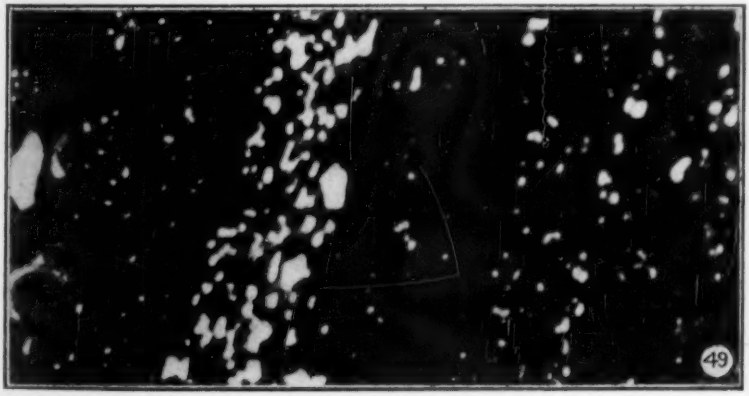


Fig. 49—Magnified 250 Diameters

Instruments Editorial Staff

RICHARD RIMBACH, *Managing Editor*

ASSOCIATE EDITORS

L. E. Barbrow....Washington, D. C.
D. L. Mathias.....Pittsburgh, Pa.
Herman Mezger.....Pittsburgh, Pa.
Arthur Schroder.....Pittsburgh, Pa.
H. Semrau.....Pittsburgh, Pa.
A. Watson, Jr.....Pittsburgh, Pa.

ABSTRACT EDITORS

J. B. Gessford.....Pittsburgh, Pa.
M. E. Haas.....Dayton, Ohio
Carl W. Kuttner.....Pittsburgh, Pa.
Q. Martin.....Pittsburgh, Pa.
G. S. Onori.....Greensburg, Pa.
M. Berg Rimbach....Pittsburgh, Pa.
A. J. Strod.....Pittsburgh, Pa.

COLLABORATORS

Prof. F. C. Ashe.....Pittsburgh, Pa.
Dr. James Aston.....Pittsburgh, Pa.
Dr. G. Berndt, Dresden, Germany
Dr. F. L. Bishop.....Pittsburgh, Pa.
Prof. W. G. Brown
.....Cambridge, Mass.
R. L. Dunlap.....Pittsburgh, Pa.
Owen W. Ellis.....Pittsburgh, Pa.
Dr. W. Ewald.....Berlin, Germany
Paul B. Findley, New York, N.Y.
A. A. Grubb.....Mansfield, Ohio
Prof. J. B. Grumbein
.....Morgantown, W. Va.
Robert G. Guthrie.....Chicago, Ill.
Prof. Lester Hamilton
.....Cambridge, Mass.
John L. Hodgson, Eggington, Eng.
Prof. George Hosmer
.....Cambridge, Mass.
Herman A. Holz, New York, N.Y.
Prof. J. W. Howard
.....Cambridge, Mass.
Hofrat Prof. Hans von Jueptner
.....Vienna, Austria
Dr. Friedrich Koerber
.....Duesseldorf, Germany
Dr. V. N. Krivibok, Pittsburgh, Pa.
A. A. Lebedeff, Leningrad, Russia
Richard R. Moore.....Dayton, Ohio
Dr. Allan Leslie Norbury
.....Birmingham, England
Prof. P. H. Schweitzer
.....State College, Pa.
Dr. Harry Seltz.....Pittsburgh, Pa.
Dr. S. R. Williams, Amherst, Mass.
Prof. W. R. Work, Pittsburgh, Pa.
C. B. Wright, Pittsburgh, Pa.

A Résumé of the Magnetic Methods Employed In Studying the Mechanical Properties of Matter

*By Dr. S. R. Williams, Amherst, Mass.**

ANY magnetic phenomenon which can be studied or discovered in any substance whatsoever, if it leads to a further knowledge of the mechanical properties of the substance, may be called a magnetic method for studying the mechanical properties of such a body. For convenience we may speak of such studies as the MAGNETIC MECHANICAL ANALYSIS OF MATTER.

Eventually this method of analysis will be applied to all bodies whether they are magnetic or non-magnetic. Better technique, however, must be developed, particularly for non-magnetic substances, as we progress in this art. That there is a very vital relation between the magnetic and mechanical properties of matter has been pointed out repeatedly by various investigators.[1] In speaking about the method of magnetic analysis St. John[2] said, "It is time to stop asking the question 'Can we afford to use this method?' and start asking 'Can we afford not to?'" The fact that Associations like the American Society for Steel Treating and the American Society for Testing Materials would put on their annual program symposia concerning Magnetic Mechanical Analysis of Materials, particularly ferromagnetic substances, indicates the growing importance of this field of investigation.

Much of the work on magnetic analysis which has been made public is largely that of the experimentalist. There is a real need for the practical man, associated with the instrument maker, to take these outfits, which seem to work satisfactorily in the laboratory, and try them out in the shop and field. Unfortunately no reports have been published by the practical man indicating that any of these methods can be successfully used in the shop. The experimentalist is concerned primarily with relations seeking to correlate one effect with another. The practical man wants some device that will indicate definite defects and measure variations in physical and chemical properties. He wants a method that will do this accurately and with economy of time. Laboratory tests have gone far enough to show the practicability of such methods. Improved methods and apparatus must now follow.

1 Joule, Phil. Mag., 30, p. 76 and p. 225, 1847.
Burrows, Bul. Bur. Stands., 13, p. 173, 1916.
Williams, Bul. Nat'l Research Council, 3, No. 18, p. 214, 1922.

2 St. John, "Discussion on Magnetic Analysis," Proc. A. S. T. M., Vol. 26, 1926.

*Fayerweather Laboratory of Physics, Amherst College.

One of the most vital relations between magnetism and mechanical properties was discovered by Joule[1] in 1847. At the suggestion of a blacksmith (a happy uniting of the practical and the experimental), Joule looked for a change in length of an iron rod when it was magnetized. This he was able to find and it has since been known as the Joule Magnetostrictive Effect, a direct relation between a magnetic

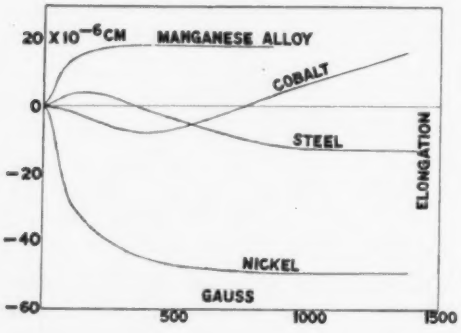


Fig. 1. Showing the change in length per centimeter of various metals as the magnetizing force is varied.

stress and a mechanical strain. Joule found that a bar of iron *increased* its length when magnetized. Later Bidwell[2] discovered that when large magnetizing forces were applied the rod contracted and became shorter than in the *magnetized* condition. Fig. 1 shows the way in which iron, nickel, cobalt and alloys of manganese change their length as the field increases from 0 up to 1400 gauss. While these curves are typical of

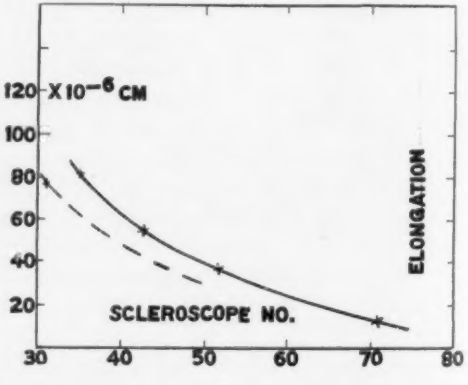


Fig. 2. These values represent the total maximum elongation for steel rods 58.5 cm. long.

such materials, they are profoundly influenced by the hardness, carbon content, temperature and other physical and chemical variations. *For every physical and chemical change there is a corresponding variation in the magnetic properties.* A recent Report[3] of the National Research

1 Joule, 1. c.
2 Bidwell, Proc. Roy. Soc., 55, p. 228, 1894; 56, p. 94, 1894.
3 Williams, J. O. S. A., 14, p. 383, 1927.

Council describes various methods for measuring these magnetic changes in length.

The Joule Effect has been applied to the study of variation in hardness[1] in both a series of steel and nickel rods. It seems more adaptable to steel than to nickel, because after a certain degree of hardness is attained in nickel, further hardening by cold rolling does not vary the effect found by Joule. In the case of steel the different degrees of hardness obtained by heat treatment change the value of the maximum elongation in a very definite way. If one were testing a series of steel rods whose chemical properties were the same, but varied only in hardness, it would be quite feasible to construct a simple device for measuring these values

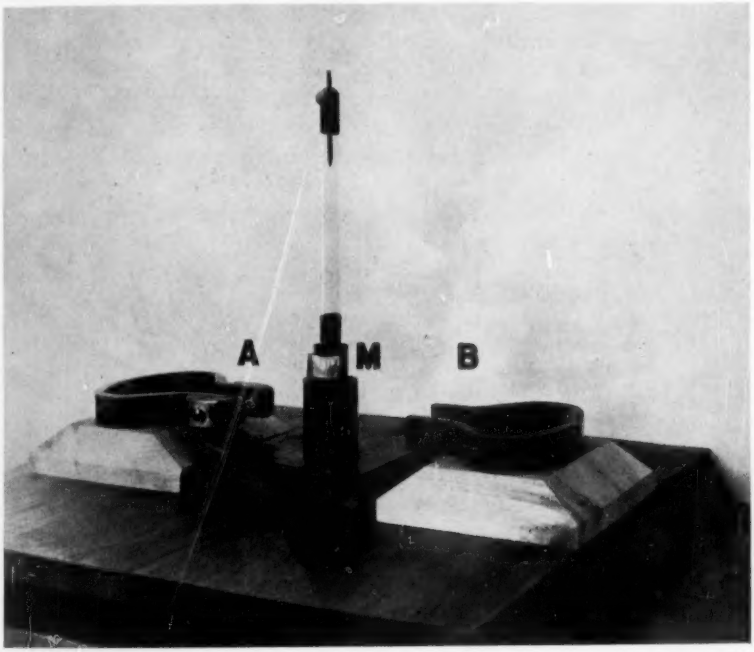


Fig. 3. A steel ball placed between the poles of the permanent magnet A disturbs the resultant field between the two magnets, producing a deflection of the magnetometer. This deflection may be used as a measure of the hardness of the steel ball.

of greatest elongation and by that means separate the soft from the hard. In Fig. 2 the greatest increase in length of a series of 1.29 carbon steel rods are plotted with respect to their scleroscope numbers. Inasmuch as the rods were all 58.5 cm. in length their total elongation is plotted, because in the simple form of magnetic hardometer for steel rods, it would in all probability be used with a bar of standard length. The continuous

1 Williams, Trans. A.S.S.T., p. 367, Apr. 1924; June, 1927.

line in Fig. 2 indicates the maximum elongation of four different rods when their drawing temperatures were maintained for 15 minutes. The broken line indicates what doubtless would be the values if the drawing temperatures were maintained two hours.

A recent laboratory device[1] for testing the hardness of steel balls by magnetic means seems to have some possibilities (Fig. 3). It depends upon the fact that when a steel ball is placed between the poles of a horse-shoe magnet, the external field is greatly reduced. A magnetometer placed in this external field will give deflections differing with the softness or hardness of the steel balls. The softer the ball, the greater will be the deflection of the magnetometer. In devising this outfit two horse-shoe magnets, A and B, were placed on a board with their poles opposing each other as in Fig. 3. Very close to the neutral point of the fields of the two magnets a small bell-shaped magnet was hung as a magnetometer M. When a ball is placed between the poles of one of the magnets, the neutral part is displaced and the magnetometer deflected. Fig. 4 shows the magnetic field between the two magnets and the distance AB through which the neutral point is shifted by the introduction of the steel balls

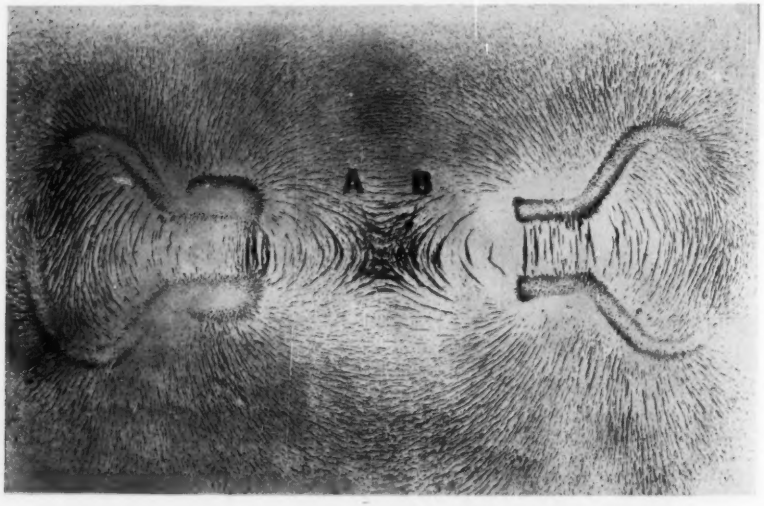


Fig. 4. When the steel ball is not between the poles of the magnet the neutral point lies at B. When the ball is placed between the poles this point is shifted to A. If magnetometer is placed at B, a resulting deflection occurs.

between the poles of one of the magnets. By reversing the numbers on the scale, large scale numbers may be taken to represent greater degrees of hardness. Fig. 5 shows the relation between numbers for the magnetic tester, the Rockwell hardness tester and rebound.

1 Williams, Trans. A.S.S.T. 5,479, 1924; 8, p. 677, 1927.

Perhaps the most desirable magnetic test is the one that will discover flaws and other mechanical imperfections. Not only in the laboratory would this be advantageous, but what would be most desirable of all is an instrument which can be carried directly into the shop or field and any member of a structure tested where it is being used. One of the earliest applications of magnetism to such a test was made by McCann

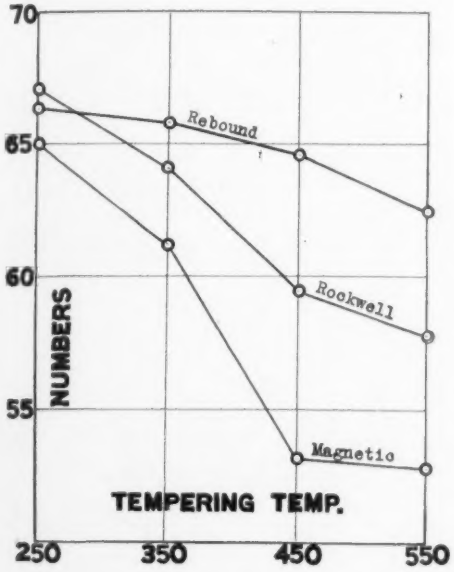


Fig. 5. The numbers for different hardness tests compared with the tempering temperature.

and Colson[1] in testing elevator cables. A magnetizing solenoid S was built around the cable as in Fig. 6. When the elevator car moved up or down, the cable passed through the solenoid and was magnetized by an interrupted or alternating current. Any inhomogeneities or variations in cross-section in the cable would induce a varying emf in the solenoid which would be indicated on the instrument V. The sections of the cable where these superimposed emfs were developed indicated to the observers where they should inspect the steel rope for broken strands or other lacks of homogeneity. The recording instrument V also had a pointer showing the cross-section of the cable as it passed through the solenoid. This affords one of the striking instances where magnetic tests could be applied in a practical way to testing mechanical conditions.

Sanford and Kouwenhaven[2] improved this method very much but depended, nevertheless, on the inductive effects due to inhomogeneities. Instead of passing the material to be observed through the solenoid, as did McCann and Colson, they moved the magnetizing and exploring coils

1 McCann and Colson, Wes. Elect., 43, p. 76, 1908.
2 Sanford and Kouwenhaven, Sci. Paper, No. 343. Bur. Stands., p. 219, Oct. 3, 1919.

along the specimen. The particular end in view of these observers was a method of testing bar stock from which rifle barrels were to be made. Fig. 7 shows a schematic drawing of their outfit. S is the magnetizing solenoid, inside of which were three exploring coils, A, B and C. A and C were connected in series and in such a way that their inductive effects were opposed to each other. By means of the switch W either A and C or B could be connected to the galvanometer G. As this system moved along the bar R magnetizing that portion inside of the solenoid, no variation in total flux through A and C or B would occur unless some inhomogeneity in the bar occurred. If an emf developed the bar could be rejected or tested further by other means. After this outfit was found to work in the laboratory it was turned over to a manufacturing concern for further trials. A report as to the practicability of the outfit would be of great interest. It is always a long road from a laboratory outfit to a device practical in the shop or field. The establishment of an organization like the Iron and Steel Institutes of many foreign countries would be a big factor in helping to develop testing devices such as have been described.

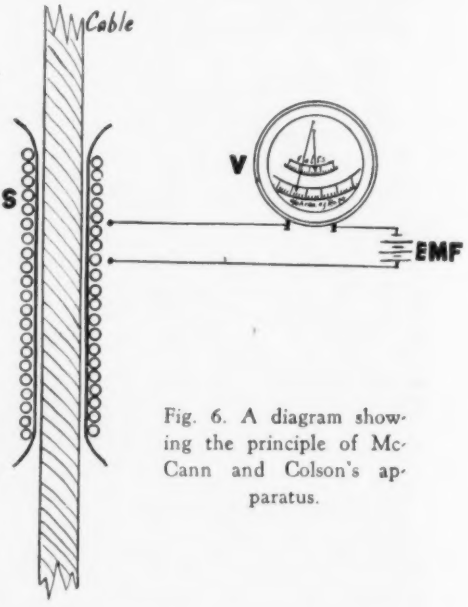


Fig. 6. A diagram showing the principle of McCann and Colson's apparatus.

The work of Burrows[1] and his collaborators gave a great impetus to the work of magnetic-mechanical analysis. His work was founded on a careful study of the "Relation of the Magnetic to the Other Characteristics of Steel." *All magnetic-mechanical analysis must ultimately rest upon a comprehensive study of the relations between magnetic and mechanical properties.* This cannot be too strongly emphasized and there is still much work to be done along this line.

One piece of work growing out of this study by Burrows was a method for exploring railroad rails when brought into the laboratory. The method finally used consisted of a single magnetizing coil arranged with either one or two test coils fitting as closely as possible to the rail. Fig. 7 gives

1 Burrows, Sci. Paper, No. 272, Bur. Stands., p. 173, Mch., 1916. Burrows and Fahy, Proc. A.S.T.M. Vol. 19, 1919.

a general idea of the principle employed. The bar R, however, would be replaced by the railroad rail in Burrow's work. One very striking result from Burrow's investigations was to show that a used rail varied regularly with the positions which the ties occupied under the rails. "The position of maximum magnetic hardness comes in the region between the ties."

Sanford and Fisher[1] used a rotating hysteresis apparatus for testing ball bearing races. According to Styri[2] his model patterned after Sanford and Fisher was not rugged and sensitive enough for shop use. As a result Styri and his associates devised an A.C. method in which the ball race served as a short circuited secondary shown in Fig. 8. This was further improved by balancing the emf developed in the secondary search coil against the emf from a similar system. In the latter a standard ball race was used. With this outfit it was possible to distinguish easily the annealed from the hardened rings by one reading. The A.C. method which was first used by McCann and Colson is one of methods that has not been developed as much as it should be in magnetic testing.

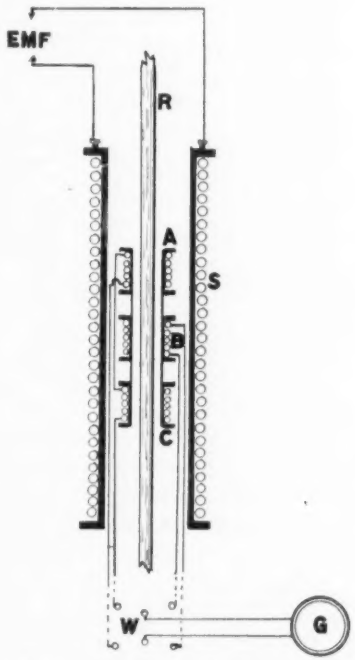


Fig. 7. Illustrating the general principle employed in Sanford and Kouwenhaven's work.

In 1916 attention[3] was called to the desirability of utilizing a portable outfit which could be employed anywhere—laboratory, shop or field—and on sections of any structure which could not be moved to a laboratory. The device used by McCann and Colson on the elevator cable had just this feature that the cable could be tested while the elevator was in use. A small portable outfit for passing over iron and steel parts was built as shown in Fig. 9. This device depends upon the variation in leakage rather than on the total flux. The electromagnet ABCD completes its magnetic circuit to a large extent through the poles, N and S, and the piece L-M which is being tested. There will always be some leakage from A to B which will be greater as the reluctivity through L-M increases. An emf will be developed in the coils S and S′ connected to the galva-

1 Sanford and Fisher, Proc. A.S.T.M. 19, Pt. 2, p. 68, 1919.
2 Styri, Proc. A.S.T.M. 26, 1926.
3 Williams, Journ. Cleveland Eng. Soc. p. 183, Jan. 1917.

nometer G when the leakage varies. With this simple device, the size of one's fist, segregations and transverse cracks could be picked out and demonstrated to an audience.

Recently Suzuki[1] of the Research Office of the Japanese Government Railway applied this principle to a device for testing rails in position. The whole outfit was mounted on a small four wheeled car and as the car moved along the rails the deflections of the galvanometer were recorded on a moving sheet of paper. Suzuki was able with his instrument to pick out three kinds of internal defects of railroad rails:

"(a) Internal cracks, cavities, blow holes.
(b) Segregation of impurities.
(c) Abnormal internal stresses."

Furthermore, "simplicity, distinctness and accuracy in detecting various effects and portability" are among the merits claimed by Suzuki for his defectoscope.

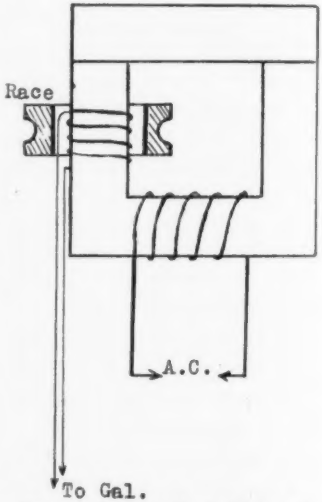


Fig. 8. A.C. method. Using circular induced currents.

The various devices thus far described are, for the most part, those in which the deflection of the observing instrument indicates directly either a flaw or some mechanical property. A large amount of work has been done in which the observations are not so direct and yet just as much a part of this program of magnetic mechanical analysis as those already described. This work is really the most fundamental of all. The sure foundation of this mode of analysis rests upon comprehensive study and correlation of coercive force, drawing temperature, hardness, magnetic change in length or any magnetic transformation which occurs when a chemical or physical substance changes, such as when a steel goes through a cycle of heat treatment. Some of these can be followed more accurately by magnetic means than by other methods. Honda[2] and his students have shown in their studies[3] of the A_1, A_2, and A_3 transformations that "If a substance undergoes an allotropic transformation at a given temperature, the magnetization or magnetic susceptability is abruptly changed."

A whole series of names could be listed among those who have helped to lay the foundations of this work, besides those already mentioned.

1 Suzuki, Sci. Rep. Tohoku Imp. Univ., 15, p. 479, 1926.
2 Honda, Journ. Iron and Steel Institute, Sept. 1916.
3 Honda and Murakami, Sci. Rep. Tohoku Imp. Univ., 6, p. 23, 1917.
Honda, Journ. Iron and Steel Institute, Sept. 1918.

Gebert[1], Spooner[2], Ishiwari[3], and Nusbaum[4] are a few names among many that one recalls in this connection. The Federated Engineers Development Corporation[5] gives an interesting account of some of their developments in magnetic mechanical analysis.

Summing up the progress thus far made in this field of analysis there is every encouragement to carry on. There are many difficulties to be overcome and we should not let our enthusiasm carry us away. Not infrequently the statement is made that magnetic analysis is the only method for testing metals which does not injure the specimen. This is not so, for considerable success is being attained in X-ray analysis. Cooperation between these two fields, by the way, is very desirable. Nausbaum[6] has summed up the various types of magnetic mechanical analysis in an admirable way by classing them under four heads:

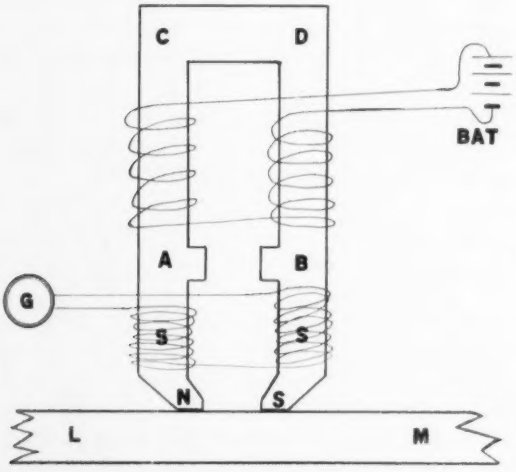


Fig. 9. A small portable outfit for magnetic-mechanical analysis.

"1. The detection by magnetic methods of inhomogeneities or non-uniformities in raw materials and finished steel products.

2. The detection by magnetic methods of physical and chemical transformations which take place in iron or steel on heating or cooling.

3. The establishing of magnetic criteria for inferring the physical constitution of carbon and alloy steel as a result of a thorough study of their magnetic properties as related to their metallogrophic structure.

4. The establishing of general though definite relationships between the magnetic and the mechanical properties of these alloys. If such general relationships can be established, then the task of predicting the me-

1 Gebert, Journ. Amer. Steel Treating Soc., June 1919.
2 Spooner, Proc. A.S.T.M. Vol. 26, 1926.
3 Ishiwari, Sci. Rep. Tohoku Imp. Univ., Vol. 6, No. 5.
4 Nusbaum, Proc. A.S.T.M. Vol. 19, 1919.
5 Fedco News, 2, 37, July 1923.
6 Nusbaum, l. c.

chanical performance of a steel product from its magnetic properties will be rendered comparatively simple and not impossible of accomplishment, as it seems at the present time."

This classification of the various phases of magnetic-mechanical analysis was applied primarily to magnetic materials.

It is time to take a forward step and say that with the development of technique, non-magnetic substances may be studied in a similar way.

An attempt to solve the problem for non-magnetic bodies will make the work simple for magnetic substances. An outfit which could pick out flaws in non-magnetic materials would be hypersensitive to flaws in magnetic bodies. The magnetic balance of Curie[1] has possibilities along this line. Geologists, by piecing together one fact after another, have unravelled much of the story of the earth's history. In the field of magnetic-mechanical analysis a similar treatment will bring the magnetic story of mechanical properties and this can come only through painstaking labor in correlating all the magnetic and mechanical facts we possess or develop by research.

The experiments described in this resume have been selected with the idea that the apparatus employed in each research is capable of further development by instrument makers into more practical devices.

———::———

PARTS of the human body formed the first units of measurement the inch having developed from the length of the thumb joint. The old measurement called the "hand" was the four inches across the human hand, and the span, nine inches, came from the space from the end of the thumb to the end of the extended little finger. As its name implies, the foot came from the length of a man's foot. The distance from the elbow to the end of the middle finger is about 18 inches and from this came the cubit, an old measure of about that length. Other old measurements included the yard, originally meaning an arm's length from the chest, or a stride; and the fathom, six feet, being gauged by a man's height or by his reach with both arms. The verb fathom is still used, and means to reach or to get the depth of a body of water. At first the league meant an hour's actual walk, and now it means about three miles.

1 Curie, Ann. d. Chem. et Phys., 7, p. 289, 1895.

Sand Tests—What Do They Mean?

*By A. A. Grubb, Mansfield, Ohio**

RECENTLY there has been a great deal of interest in the more or less scientific examination of foundry sands. Formerly almost all sand testing was by feel or visual examination. In many cases such tests were entirely satisfactory, in others they were valueless. Some of our molders were artists in their line and not only was their molding technique of a high order, but their judgment of the molding properties of sand was remarkably accurate. With the introduction of molding machines, sand slingers and sand handling equipment, the old time molder is being replaced by machine operators of much less real molding ability. Control of molding sand by feel or by visual examination by such operators is of most questionable value: the personal equation is tremendous. The sand becomes the alibi for almost every trouble they experience, and even when it is the weak cog in the wheel, the fact is discovered only after the molds are poured and the castings examined.

Screen tests and chemical analysis were probably the first tests used to supplement the "feel method" of selecting sands for use in the foundry. Screen tests were usually made on the dried sample without removing the clay and consequently they were often misleading. Chemical analyses were expensive and few knew how to interpret them correctly. So when the American Foundrymen's Association undertook to develop suitable methods for measuring the properties of sands, there was a real need for practical test methods. Clay, grain fineness, permeability, bond strength, dye absorption, durability, and other tests were developed in rapid succession and offered to foundrymen and sand producers. Experience with these tests has been varied. In many cases they have been of great value and have resulted in more uniform shipments of sand on the part of producers and lower percentages of defective castings on the part of foundrymen. In other cases the tests have failed to accomplish the results expected of them. The writer believes that this is due largely to lack of information as to what the tests mean. We are frequently asked: "What tests should be made to control foundry molding heaps? Which of the several bond strength tests should be used? What tests should a sand producer make?"

It is not the writer's intention to try to give final answers to these questions. There is available, however, a considerable amount of information regarding the purpose and value of the tests that should help foundry men and sand producers use them intelligently.

*Director of Laboratories, Ohio Brass Company.

Foundrymen are directly interested in the bond strength, permeability, texture and refractory properties of sands. These are the working properties. Chemical composition, grain fineness, clay content, colloid content and possibly other factors determine these working properties, so are of vital importance in understanding sand control.

Chemical Composition

Molding sand analyses are usually reported in terms of silica, iron oxide, alumina, lime, magnesia, sodium oxide, potassium oxide and loss on ignition. Such analyses give no information as to the actual form in which the various elements exist; silica and small quantities of iron oxide and alumina are found as such, but in main the elements are found in more or less complex combinations such as feldspar, mica, tourmaline, horn-blende, etc. Inasmuch as the physical properties depend to a large extent upon the actual combinations in which the elements are found, care must be exercised in interpreting chemical analyses.

Chemical analysis is of most value when separate analyses on clay and grain can be obtained. The grain usually runs higher in silica and lower in iron and alumina than the clay, and so, even aside from its larger particle size, is of a composition that is more refractory.

The silica content of a sand is considered an index to its refractory properties, higher silica contents indicating greater refractoriness. This is more nearly true of free silica than of the combinations of silica with other elements, many of which are readily fusible. Silica tends to make a sand resistant to sudden changes in temperature, decreases mold distortion on drying and usually operates against plasticity or "flow properties" of sand.

Aluminum compounds vary greatly in refractory qualities. Alumina is highly refractory as is also kaolin which consists largely of aluminum silicates. Other complex aluminum silicates containing alkalies are readily fusible. In general, the aluminum compounds are not highly plastic.

Iron compounds are not as refractory as those of aluminum but are more plastic. Many of them are red or brown and impart this color to the sand or clay. It is generally believed that high iron sands peel from castings better than high alumina sands.

Lime is considered deleterious in molding sands. It usually occurs as calcium carbonate in which case it can be readily detected by the evolution of gas when muriatic acid is poured upon a sample of sand. It is undesirable because nearly all forms of calcium act as powerful fluxes and so reduce refractory properties. Calcium carbonate is readily burned into quick lime which lacks bond and breaks down, marking the casting.

Magnesia is similar to lime in its effect on sand though it is not as powerful as a flux and acts more slowly. It is, therefore, not as deleterious as lime.

Sodium and potassium are powerful fluxes and so tend to reduce refractoriness. They are usually found in the form of feldspar or mica, the latter of which is especially undesirable because of its flaky nature: moisture becomes imprisoned between the flakes and bursts them open when hot metal strikes the surface. Lime, magnesia and the alkalies, sodium and potassium, are considered impurities in sand.

Loss on ignition is considered a measure of the organic material in sand. When it does not exceed three or four percent, organic material is considered advantageous, provided it is in a finely divided state and not in the form of roots and such material. It imparts bond and "flowing qualities" to sand and improves peeling qualities. Organic material burns readily so excessive amounts result in sands that readily burn out and become weak—of low durability.

Particle Size

The particles composing a natural molding sand range in size from a tenth of an inch or larger down to less than a hundred-thousandth of an inch in diameter. The larger particles are called grain while the smaller form the clay. When separation is made by the standard method,[1] the largest particles in the clay are about one-thousandth of an inch in diameter. The dividing line between grain and clay is an arbitrary one; the coarser part of the clay is very similar to the fine grain or pan material.

Clays differ as widely in particle size as do screen analyses on the grain from various sands. Consequently they differ widely in physical properties. Particles of very finely divided material, say less than a hundred-thousandth of an inch in diameter, have properties so different from larger particles of the same chemical composition that they are known under a special name—colloids. This word is derived from the Greek word Kolla, meaning blue, and describes the characteristic property of the material very well. Such finely divided material—colloidal matter—has great absorptive properties and when wet is very sticky. Pure colloidal matter once wet and then dried has strength comparable with portland cement.

Clays in which the particles are but little smaller than a thousandth of an inch, are very weak; those which are largely colloidal are very sticky and strong. The difference in strength shows up especially in specimens which have been dried.

The grain size and grain distribution of sands can be readily measured with screens and standard methods are available. The particle size of clays is not so readily measured. Suspension and elutriation methods[2] are valuable for this purpose but are slow and tedious. By

1 Methods of Test, American Foundrymen's Assn., page 54.
2 See Ries, H., Clays, Occurrence, Properties and Uses, pp. 195-209.

measuring the quantity of dye absorbed by a sand or clays[1] an estimate of its colloid content can be obtained provided the sand is free of the burned organic material, metallic oxides, etc., usually found in heap sand. The test is satisfactory, therefore, only when used with new sands and clays. A method for measuring colloidal matter in heap sand is much needed.

Particle size is a very important factor in determining permeability and bond strength. The A.F.A. Sub-Committee on Grading[2] classified some seven hundred sets of data on new sands with view to discovering the relation between grain size, clay content, colloid content (dye adsorption value), permeability and bond. The writer has classified 290 sets of data on brass and malleable foundry heaps sands with view to determining whether the same relations hold for heap sand. The results of this classification are more consistent than those obtained with new sands because variables due to different types of sands, different clay distribution, etc., are largely eliminated. The data does not cover as wide a field, however, because it was obtained on sand from but two foundries. This work as a whole indicates that permeability is determined (1) by grain fineness, (2) by clay content and (3) by other unmeasured factors such as grain and clay distribution; that bond strength is determined (1) by colloid content (dye adsorption value), (2) by particle size, which includes both grain fineness and clay content, and (3) by other unmeasured factors.

The relation between grain fineness, clay content and permeability is sufficiently definite for very practical use. For example, Table 1 shows the permeability values that can be expected in sand heaps of various grain fineness figures, and fineness can be controlled accordingly.

The relation between colloid content, grain fineness, clay content and bond strength is not so apparent. In general, the finer the particle size, that is, the higher the grain fineness number and the clay content, the higher is the green bond. It is evident, too, that the higher the colloid content as measured by the dye adsorption value, the greater is the green bond.

Tables 2 and 4 indicate that in heap sand there is very little if any relation between the clay content of a molding heap and its green bond. A similar classification with new sands shows green bond increasing with clay content up to fifteen or twenty percent after which it remains practically constant with further increases in clay. We can only speculate as to the explanation of all this. It is probable that in new sand colloid content is proportional to clay content, but that in heap sand there is no such relation. Heat from molten metal may burn

1 Methods of Test, American Foundrymen's Assn., p. 58.
2 Trans. A.F.A., Vol. XXXIV, pp. 504-511.

out colloidal matter—dehydrate and aggregate it into large particles which are not large enough to fall into the grain class; it is still measured as clay but has little or no bonding power. It is possible then to have a molding heap show proper grain size and proper clay content and yet be too low in bond strength for satisfactory use. Such clay is useful only for providing smooth surfaces; on the other hand, it may close up the sand and reduce permeability.

Results obtained in the writer's laboratory with two highly colloidal clays are interesting in this connection. Samples of each clay were air dried, while other samples were air dried and then heated at 600°F. for two hours. Silica sand was then bonded with these samples and tested for green bond as well as for dry strength. Following is the complete data:

	CLAY No. 1		CLAY No. 2	
	Dried	Heated	Dried	Heated
Wt. of silica	1500	1500	1500	1500
Wt. of dry clay	31	31	31	31
Moisture, determined	1.3%	1.4%	1.2%	1.2%
Permeability, green	237	242	240	242
Green bond, tensile	7.0 oz.	7.1 oz.	6.4 oz.	6.7 oz.
Green bond, compression	2.8 lbs.	2.8 lbs.	2.6 lbs.	2.6 lbs.
Dry str., tensile	4340 g.	3568 g.	4312 g.	3219 g.
Loss		18%		25%
Dry str., compression	19.3 kg.	16.0 kg.	17.0 kg.	13.4 kg.
Loss		17%		22%

Heating the clay for two hours at 600°F. did not destroy its value as a green bonding agent but did effect its colloidal properties as is evidenced by the dry strength tests.

Green bond, that is, bond strength when sand is properly tempered for making molds, is absolutely necessary, but is it sufficient? There is growing opinion among investigators that sand must have appreciable strength and rigidity when the moisture has been removed, even though in practice the mold is not dried out before pouring. The writer has made up molds from silica sand bonded with silica flour of very low colloid content (dye adsorption value less than 30). The sand had permeability and green bond values that compared very favorably with the best holding sand in the shop, yet the mold cut and washed to such an extent that every casting was a failure. Such a sand is harsh to the touch. A good molding sand that contains appreciable colloidal bond has a "velvety feel."

While more experimental data along these lines is needed before definite conclusions can be drawn, there is much to indicate that colloidal material is the essential bonding agent required in molding sand;

that heat effects are first felt by the colloidal matter and evidenced by deterioration in dry strength even before it effects green bond; that further heating or higher temperatures aggregate the particles still further and deteriorate green bond strength even before it effects clay content; that still further heating or higher temperatures aggregate the clay moving it into the grain class.

Refractoriness

While chemical analysis affords information that aids in understanding the behavior of sand under heat, so much actually depends on the form in which the elements are found that it is impossible to predict the fusion point with any degree of accuracy from composition alone. Fusion point determinations should, therefore, be made where the question of refractoriness is involved. This is the case particularly with steel sands which must withstand high temperatures.

It is a well known fact that fusibility depends on particle size as well as on chemical composition so such tests are most valuable when made separately on the clay-free grain and on the clay.

The fusion points of molding sands range from about 2500°F. for some aluminum and brass sands to about 3100°F. Fire clays used in bonding steel sands fuse at temperatures from 2900° to 3150°F.

Permeability Test

The A.F.A. permeability test has become very well established as a standard. It is particularly valuable as a control test in the foundry where it serves as a quick and direct measure of the venting quality of sand when tempered and ready to go onto the pattern. By correlating permeability values with losses due to misruns and blows, the proper permeability for various types of work can be readily determined. It should be borne in mind, however, that the permeability of a heap varies with moisture content and also that moisture alone may be directly responsible for misrun or blown castings.

When applied to new sands the permeability test should be used with discretion. New sands as a rule do not have the same grain and clay distribution conditions that are found in heap sand; a sand which shows a certain permeability when new may give an entirely different figure when in use, even though the moisture content may be the same. This is especially marked in new sands of clay content over twelve or fifteen percent. Very few molding heaps are operated with more than these percentages of clay, so additions of high bond sand are made only to replace clay that is burned out. In such cases, the permeability of the new sand bears no relation to that of the heap sand. Further-

more, in new sands of high clay content, the grain and clay are massed in aggregates which may remain intact through the test unless special care is taken to break them up into separate grains or dust after drying. If this is not done, abnormally high permeability values result; if it is done, the values are apt to be lower than that of the heap in which it will be used. Chart I illustrates the differences in physical properties, bond strength as well as permeability, that may be obtained on a sand depending on the manner in which it has been handled. A sample of sand of grain fineness 70 and clay content 23% was mined wet and passed through a No. 4 riddle before test. The data represented by the solid lines A were obtained. The sample was then dried, milled and tested again. The data represented by the dotted lines B were then obtained. This sand is used without other additions in foundry heaps carrying 11 to 14% clay and the permeability ranges from 60 to 70.

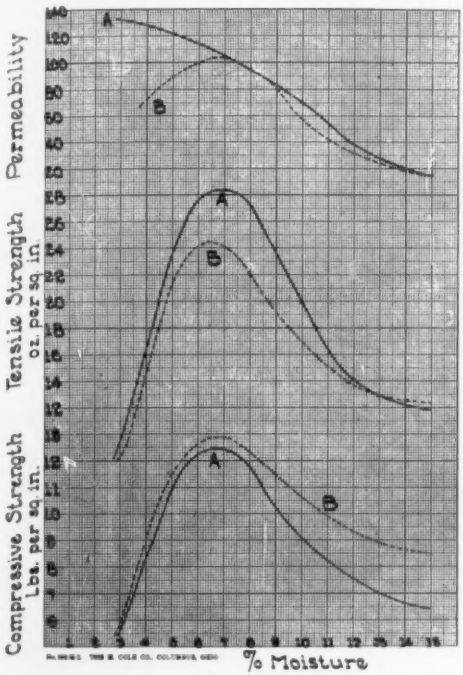


Chart I.

Bond Strength Tests

Several methods for testing green bond strength have been proposed, namely, the transverse or cohesiveness test, tensile strength, compression and shear tests. The first three of these have been made tentative standards by the A.F.A. The names imply the manner in which the breaking load is applied. There has been much discussion as to which one is the proper test and the question is still an open one. Certain facts relating to this question are available and may help one in selecting the proper test or tests.

The transverse strength test is slow and clumsy to perform and the equipment is much more expensive than that for the other tests. It

yields a bond strength number which is a function of the density of the sand as well as its actual strength and is roughly proportional to the square root of the tensile strength.

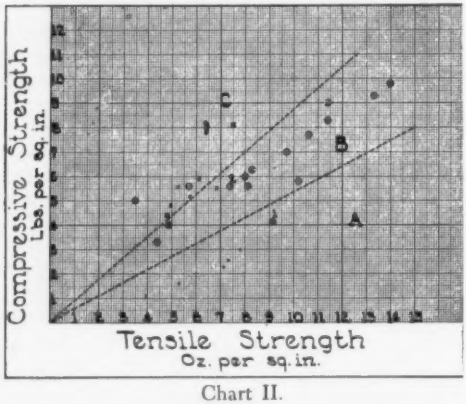


Chart II.

The relation between the compression and tensile tests is not so well understood, nor is it known just what property or properties of sand the compression test measures. For sands of similar states of aggregation, similar colloid contents and similar temper, compressive strength is roughly proportional to tensile strength. This relation does not hold when comparing radically different types of sands or even the same sands under different conditions of temper and aggregation. This is illustrated in both Charts I and II.

Chart II shows graphically the tensile and compression data on a wide variety of samples. The samples represented in zone A were very open sands of high colloidal bond; those in zone B were largely natural bonded molding sands, some of them new and some used heap sand; those in zone C were largely tight sands of rather low colloid contents or rather dry samples. As extreme examples take the three samples represented by points (1), (2) and (3). (1) is a sample of silica grain bonded with a highly colloidal clay. (2) is strong heap sand and (3) is a sample of silica flour. The complete test data available is as follows:

	Moisture %	Tensile Strength	Compression Strength	Transverse Strength
(1)	3.3	9.1	4.1	——
(2)	5.3	7.4	5.6	202
(3)	6.0	6.4	7.8	171

Which sample has the greatest bond strength? It is evident that the two tests, tensile and compression, do not measure the same property or properties. What do they measure?

There is not sufficient data available to draw definite conclusions. That which is available, however, seems to indicate that compression test values are influenced by plasticity as well as bond strength; that of two sands of equal bond strength, the one having the greatest plas-

ticity will have the lowest compression test. The very nature of the tensile test—pulling the grains apart by the direct application of force along the line in which separation takes place—marks it as a direct measurement of bond strength. This evidently was the opinion of the original sponsors of the transverse and compression tests, R. C. Doty and H. W. Dietert, each of whom endeavored to develop a tensile bond test before turning their efforts to other methods of measuring bond.

Molding sand is several times as strong in compression as in tensile strength. Failures in a mold, therefore, are more apt to occur under tensile forces than under compressive forces. Bond strength as recognized by the molder, is the strength with which sand grains are bound together and this strength is measured by the force required to pull those grains apart.

Compression and shear tests are possibly more rugged and slightly easier to perform. They are nearly enough proportional to bond strength to be of value for control purposes where but one type of sand is used. They have, therefore, come into rather wide use.

What Tests, Then?

The molder is primarily interested in bond strength and permeability. These properties can be measured directly and quickly; therefore, they are the logical subjects for control tests. Permeability and bond strength as well as other factors determining foundry losses depend on moisture content so moisture tests should be made unless sufficient control can be secured by "feel" methods. These are the primary control tests and should be made often enough to detect changes in the molding properties of the sand before those changes are registered on the casting loss chart.

The foundry foreman must know not only the bond and permeability of his sand heaps but he must also know how to make additions to those heaps that will maintain proper casting conditions. This involves information as to the grain fineness and clay content of the heaps and the new sand supplies. Such tests on the heaps need not be made frequently—only often enough to know the general trend, upward or downward, of the clay and coarser or finer as regards the grain; they should be made on sand stocks and shipments received often enough to know what is coming into stock and to insure uniform shipments. The foreman should also know enough about the chemical analysis of his sand and its colloidal properties that he can talk intelligently with the purchasing agent and the sand salesman about alkalies or lime in the sand and can appreciate the difference between a lean silty clay and a sticky "bondy" one.

The sand producer should know all about his product. The fineness and clay tests afford him a means of grading his sands and controlling their uniformity. The dye adsorption test affords him a means of evaluating the clay in his sands. Chemical analysis helps him to guard against deleterious materials that, if allowed to get into his customer's foundries, might ruin his business.

In addition to these tests, all concerned need to use with them an abundance of common sense. Molding sand technology is in its infancy; far more of it is unknown than is known. There are materials in existence that seem to have all the desirable properties of good molding sands and yet are worthless. Heap sand may have the proper moisture, bond strength and permeability and yet produce defective castings. With the tests is needed good judgment, good sand sense. It is hoped that methods and instruments will ultimately be developed that will tell the whole story regarding molding sand. When this has been done, and when sand producers and foundrymen set about to use them intelligently, then the "rotten sand" alibi will be driven from the foundry.

Table No. 1, Classified as to Grain Fineness

Fineness Zone	No. of Tests	Grain Fineness	Per Cent Clay	Permeability	Tensile Bond
110–115	15	113	10.04	27	4.13
115–120	29	117	10.55	26	4.21
120–125	51	122	10.26	25	4.52
125–130	51	127	9.56	23	4.66
130–135	49	132	8.57	20	4.80
135–140	48	137	8.30	19	4.82
140–145	32	141	8.24	18	4.88
145–150	11	147	7.78	17	4.56
150 & over	4	169	10.75	15	4.82

Table No. 2, Classified as to Clay Content

Clay Zone	No. of Tests	Grain Fineness	Per Cent Clay	Permeability	Tensile Bond
5.5–7.0	33	133	6.59	19	4.77
7.0–8.5	71	135	7.66	18	4.70
8.5–10.0	78	130	9.37	23	4.95
10.0–11.5	84	125	10.63	23	4.31
11.5–13.0	20	129	11.88	24	4.66
13.0–14.5	30	123	13.77	22	4.76

Table No. 3, Classified as to Permeability

Permeability Zone	No. of Tests	Grain Fineness	Per Cent Clay	Permeability	Tensile Bond
13–16	13	147	8.71	14	4.80
16–19	65	149	8.66	17	4.92
19–21	49	135	8.08	19	4.77
21–24	57	129	9.08	22	4.62
24–27	46	119	10.49	25	4.38
27–30	37	120	10.26	27	4.35
30–33	9	121	10.37	30	4.35
33–36	2	125	10.12	33	4.24
36–40	2	115	11.11	39	3.78

Table No. 4, Classified as to Bond (Tensile)

Bond Zone	No. of Tests	Grain Fineness	Per Cent Clay	Permeability	Tensile Bond
3.5–3.7	1	111	12.80	38	3.61
3.7–3.9	2	118	9.96	26	3.74
3.9–4.1	22	123	9.38	25	3.96
4.1–4.2	14	120	10.62	25	4.14
4.2–4.3	56	124	9.96	24	4.31
4.3–4.6	34	134	9.18	22	4.48
4.6–4.8	48	131	9.23	22	4.66
4.8–4.9	25	127	9.08	21	4.84
4.9–5.1	43	134	8.36	19	4.99
5.1–5.3	14	137	8.68	18	5.16
5.3–5.5	16	133	8.85	19	5.33
5.5–5.7	6	137	8.86	18	5.55

———::———

THE COMPASS: Records show that Chow Kung in the Chow Dynasty, about 1122 D.C. used a kind of wagon equipped with an instrument that always pointed toward the north.

———::———

SEISMOGRAPH: An instrument, resembling perhaps the present-day seismograph, was invented by Chang Heng in the first century, during the Han Dynasty, which could record any slight earthquake not perceptible by human senses.

Contents of Subsequent Issues

Historical Sketches of Men who have contributed to the advancement of the Instrument Science.
Temperature control in Process Industries.
The Testing of Hardness.
Correct Connections for Polyphase Watt Meters.
Electrical Insulation and its Measurement.
Measuring to Four Parts in a Billion.
Humidity Test Equipment.
The Measurement of High Temperature by Radiation Pyrometers.
Modern Precision Measuring Tools for Machine Shop Use.
The Measurement of Luster.
Aeronautical Instruments.
The History of the Electric Meter.
Organization in Research.
Weighing Devices.
Conservation through Metering.
The Measurement of Illumination.
Flow Measurement.
Automatic Combustion Control.
Optical Pyrometry.
Thermometry.
The Importance of Measurements in the Power Plant.
The Care of Measuring Instruments.
Equipment Used in Aerial Surveying.
Automatic Control of High Temperatures.
The Measurement of Boiler Combustion Zone Temperatures.
Fluid Meters.
Instruments for Geodetic Prospecting.
Dilatometry.
The Measurement of Pressure.
Speed Recording Instruments
Engine Indicators.
Instruments applied to the Open Hearth for Efficiency.
Thermoradiometers.
Mechanical Vibrations and Their Measurement.
Instruments to improve Diesel Engine Efficiency.

A Portable Photometer for Measuring Colored Light

By Louis E. Barbrow, Washington, D. C.

GENERALLY in practical photometry, it can be assumed that the surfaces illuminated by two light sources to be compared with each other, are of the same color. This being the case, errors due to color difference are not introduced. If, however, the intensity of a colored light source is required, difficulties arise in the determination of its luminous intensity. Several devices and methods have been introduced to overcome these difficulties; none of these devices however, has been of the portable type such as is herein described.

In comparing lights of different colors, absolute equality, of course, cannot be obtained because the things being compared differ in kind as well as in degree. We know, however, that regardless of the difference in kind, the eye can estimate equality in degree within certain limits, varying of course with the extent of the difference of kind. For example, if even a red signal and a green signal be compared, we know that the brightness of the green signal can be increased until there is no doubt but that it is brighter than the red signal. It is the purpose of heterochromatic photometry to reduce as far as possible the limits within which these sources of different colors appear to be of the same intensity.

In the work to date, use has been made most frequently of the Flicker Photometer where measurements involving color differences are to be made. The use of colored glass or gelatine filters has also found application in photometric measurements, as has also the Cascade Method, which divides the existing color difference into a number of small steps. Other principles have also been applied to this problem, but the three methods mentioned are probably the most important.

In the Flicker Photometer, the surfaces to be compared are presented in rapid alternation to the eye of the observer, and their relative brightness altered until no flicker is observed at a fairly low frequency of alternation. The second method mentioned involves the placing of colored filters between the standard lamp and the photometer head. The calibration of the standard lamp for each filter used is necessary in this case. The Cascade Method can be applied only in laboratory practice and this of course, eliminates it for use in a portable photometer.

Of the two practical methods left for use in a portable photometer the flicker photometer is the less suitable since it requires a motor for rotating the optical device, and also a slightly more complicated form of optical device than is usually used. The use of colored filters appears,

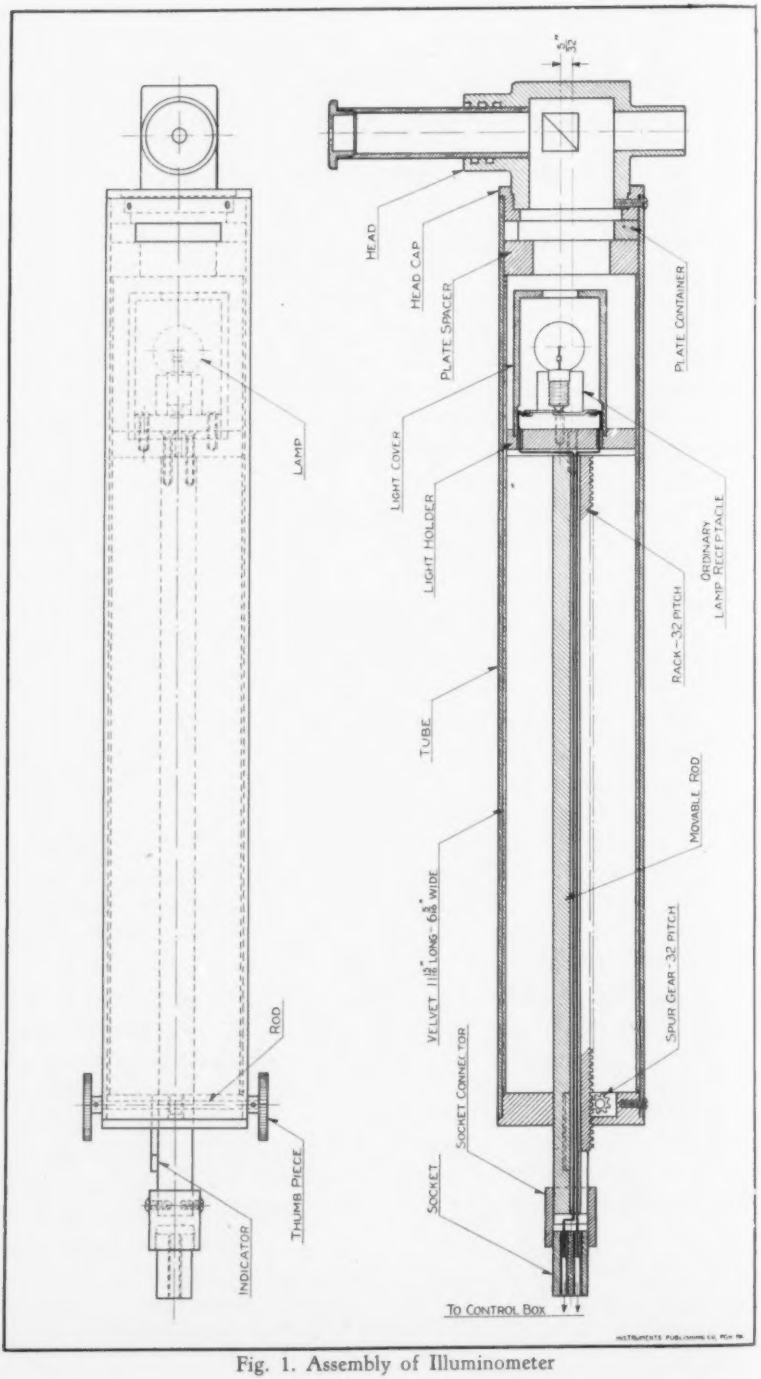


Fig. 1. Assembly of Illuminometer

therefore to be most suitable for a portable photometer for measuring colored light since the accessories needed for its operation are small and since a group of filters can be calibrated in a photometric laboratory and then used in the portable photometer.

The Macbeth Illuminometer has found extensive use in practical illumination measurements and its general design was followed in constructing the new photometer. A Lummer-Brodhun Cube, similar to that used generally for work of great accuracy in comparing light sources of the same color, serves as the essential part of the photometric arrangement. The cube is so mounted that it can be removed for cleaning and then easily be replaced.

The tube of the original apparatus was nine inches long and 1¾ inches in diameter. In this tube a diaphramed carriage moves, within which a miniature electric lamp is mounted. This lamp is designated as the working standard. From previous experience it was found that the maximum value obtainable with the particular working standard designed for the apparatus was too low and that if this condition was remedied by increasing the size of the light alone the use of the instrument for measuring lower values would be out of question. It was decided then to use a working standard of higher intensity and to increase the length of the tube to such an extent that the lower limit could not be affected. This part was finally made of seamless aluminum tubing, inside and outside diameters 2 and 2⅛ inches respectively. The length was increased to 13⅜ inches. The tube was lined with short nap velvet so that the only light reaching the optical device comes directly from the standard, none arriving due to reflection. The lamp chosen was of the miniature incandescent type obtained from the National Lamp Works, and suitable for operation between 2 and 2.3 volts.

The lamp carriage is moved up and down in the tube by means of a substantial rack and pinion, operating on a round aluminum rod to which the carriage is fastened.

The arrangement for the insertion of the colored plates and its location with respect to the complete apparatus as shown in Fig. 1, an assembly drawing of the apparatus. Two hard rubber discs are separated by a third disc, the thickness of which is equal to the thickness of the holder of the plate. The upper of the two discs serves also as a head cap.

Using the instrument as described, with red filter inserted, and checking results against values obtained with a Flicker Photometer, data as given in the graph (Fig. 2) was obtained. It will be noticed from this curve that with the exception of low intensities, the relation between the two values is constant and a straight line is obtained as a result. It will be necessary now to calibrate a group of colored filters so

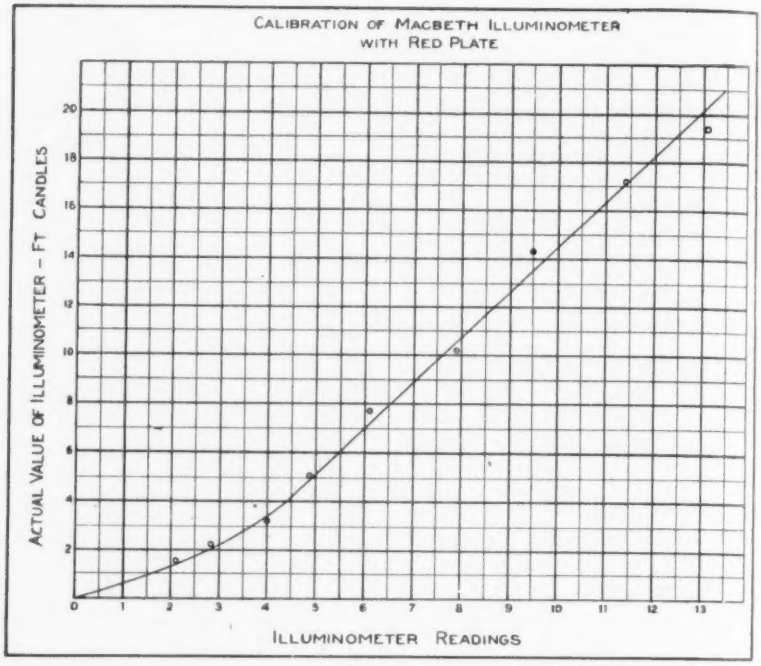


Fig. 2.

that they may be placed in the instrument when desired, so as to effect a suitable color match. Judging from the results obtained in the relatively small amount of experimental work done with this photometer thus far, it can be hoped that the additional work contemplated will go far in solving the problems of quickly measuring colored light intensities.

Complete Gas Analysis by the Simultaneous Oxydation of Methane, Carbon Monoxide and Hydrogen

By Hofrat Professor von Jueptner, Vienna, Austria

A COMPLETE analysis of gases, which contain in addition to oxygen and nitrogen, hydrogen, carbon monoxide, carbon dioxide, methane and heavy hydrocarbons, involves many difficulties. These difficulties can be overcome by following the method suggested by Dr. Hans Kress[1]) of Cologne, which consists of the combined combustion of hydrogen, carbon monoxide and methane. The apparatus for the analysis is an explosion pipette provided with a 3-way stopcock and a cooling jacket to insure speedy cooling of the gases after the combustion has been completed. Three absorption pipettes are provided for carbon dioxide, heavy hydrocarbons and oxygen.

A sample of gas is taken (100 cc.) and the carbon dioxide, heavy hydrogens and oxygen are absorbed in the usual manner; the decrease in volume after each absorption indicates the amount of the above mentioned constituents. For example:

Original volume of gas sample 100 cm^3.	
After the absorption of carbon dioxide 96.3; $CO_2 = 100.0 - 96.3$	$= 3.7\%$
After the absorption of heavy hydrocarbons 93.6; Heavy hydrocarbons $= 96.3 - 93.6$	$= 2.7\%$
After the absorption of free oxygen 92.8; oxygen $= 93.6 - 92.8$	$= 0.8\%$
	7.2%

Of the gas remaining (92.8 $cm.^3$), 15 $cm.^3$ are transferred to the explosion pipette mixed with 75 $cm.^3$ of air exploded by means of an electric spark. Kress assumes the air contains 20% oxygen and 80% nitrogen. This to a certain extent compensates for the water vapor in the air.

From this is obtained:

Volume of the gas remainder and the air added $15 + 75$	$= 90.0$ $cm.^3$
Volume of the gas after the explosion and cooling to room temperature	$= 70.9$ $cm.^3$
Contraction c	$= 19.1$ $cm.^3$

The carbon dioxide and excess oxygen produced by the explosion are absorbed, and it is found;

After the Carbon dioxide absorption 65.4 $cm.^3$, $CO_2 = 70.9 - 65.4$	$= 5.5$ $cm.^3$
After the oxygen absorption 61.1 $cm.^3$, $O_2 = 65.4 - 61.1$	$= 4.3$ $cm.^3$
Therefore the nitrogen in the combustion products	$= 61.1$ $cm.^3$
According to the above 75 $cm.^3$ of air contain 75×0.8 of N_2	$= 60.0$ $cm.^3$
the nitrogen content of the analyzed gas N_2	$= 1.1$

1 See "Die Messtechnik" 1926, page 346.

The volume of hydrogen, carbon monoxide and methane contained in the burned 15 cm.³ of gas remainder, are determined by the following calculation: The burned gases contain an amount of hydrogen, carbon monoxide and methane $V = 15.0 - N_2 = 15.0 - 1.1 = 13.9$ cm.³.

Due to the fact that carbon monoxide and methane when burned produce a volume of carbon dioxide equal to their own volume, we find that the volume of hydrogen is $15.0 - N_2 - CO_2 = 15.0 - 1.1. - 5.5 = 8.4$ cm.³.

The contraction for the individual gas constituents, is calculated as follows:

$2H_2 + O_2 = 2\ H_2O$; Contraction, because the water is condensed	$= \frac{3}{2}\ H_2$
$2CO + O_2 = 2\ CO_2$; Contraction	$= \frac{1}{2}\ CO$
$CH_4 + 3\ O_2 = CO_2 + 2H_2O$; Contraction because the water is condensed	$= 2\ CH_4$
Therefore the total contraction	$C = \frac{3}{2}\ H_2 + \frac{1}{2}\ CO + 2\ CH_4$

As the carbon monoxide and methane have on combustion their original volumes, we have $CO_2 = CO + CH_4$ and $\frac{1}{2}CO + 2\ CH_4 = C - \frac{3}{2}\ H_2$

Finally, if we designate the total reduction in volume after combustion and the absorption of the carbon dioxide C_1 we have

$C_1 = C + CO_2 = \frac{3}{2}\ H_2 + \frac{3}{2}\ CO + 3\ CH_4$
and $\frac{2}{3}\ C^1 = \frac{2}{3}\ (C + CO_2) = H_2 + CO + 2\ CH_4$

Volume of the combustible constituents	$V = 15.0 - N_2 = H_2 + CO + CH_4$
	$\frac{2}{3}\ C^1 - V = CH_4$

and as

CO_2	$= CO + CH_4$
$CO = V + CO_2 - \frac{2}{3}\ C^1$	

This gives the following values for our problem:

$CO = 15.0 - 1.1 + 5.5 - \frac{2}{3}\ (19.1 + 5.5) = 19.4 - \frac{2}{3} \cdot 24.6 = 19.4 - 16.4$	$= 3.0$ cm.³
$CH_4 = \frac{2}{3}\ (19.1 + 5.5) - (15.0 - 1.1) = 16.4 - 13.9$	$= 2.4$ cm.³

All these volumes refer to our 15 cm.³ gas remainder and must be recalculated for the remaining combustible constituents and the original gas sample (92.8 cm.³) after the absorption of the carbon dioxide, heavy hydrocarbons and oxygen.

Carbon dioxide determined directly		3.7%	by volume
Heavy Hydrocarbons		2.7%	" "
Free Oxygen		0.8%	" "
Nitrogen (from the burned gas quantities)	$\frac{1.1 \times 92.8}{15.0}$	6.8%	" "
Hydrogen (from the burned gas quantities)	$\frac{8.4 \times 92.8}{15.0}$	51.97%	" "
Carbon Monoxide (from the burned gas quantities)	$\frac{3.0 \times 92.8}{15.0}$	18.56%	" "
Methane (from the burned gas quantities)	$\frac{2.5 \times 92.8}{15.0}$	15.47%	" "
	Total	100.00%	

The calculation can be very much simplified if in place of taking 15 cm.³ of the gas remainder, a fractional part is taken (for example $\frac{1}{5}$, i. e. $92.8 \div 5 = 18.56$ cm.³), mixed with a fivefold quantity of air (92.8 cm.³) and burned.

In that case we would have

Hydrogen	$= 10.4$ cm.³ $\times 5 = 52.0\%$ by volume
Carbon Monoxide	$= 3.7$ cm.³ $\times 5 = 18.5\%$ by volume
Methane	$= 3.1$ cm.³ $\times 5 = 15.5\%$ by volume

Added to this as above	
Carbon Dioxide	3.7% by volume
Heavy Hydrocarbons	2.7% by volume
Free Oxygens	0.8% by volume
Nitrogen	6.8% by volume
Total	100.0%

::

Instruments Is a New Periodical With a Wide Field of Usefulness

EVERY article appearing in INSTRUMENTS begins on the right hand page, the pages are numbered consecutively and side wire stitched. This makes it possible for each reader to build up a technical record of the articles in the form best adapted to the needs of the reader:

1. All issues of the journal can be collected and bound into an annual volume.
2. The technical information appearing during the year can be assembled according to subjects.
3. The single articles may be assembled in loose leaf note-books, binders or in filing jackets or in any manner desired by the reader.

In addition to the regular table of contents, there is a 3x5 file card section carrying the title, author, volume, number of issue, and date and pages on which all original articles may be found. These are bound in the back of each issue and when cut out and filed give ready access to important instrument information, which the reader may be searching for at some future time.

INSTRUMENTS is indispensable for

The OPERATING MAN, for reference purposes or to increase his technical knowledge;

The SPECIALIST, who must follow all the developments in instruments in his special field;

The INVESTIGATOR and SCIENTIST, who desire to follow the developments in instruments outside their own field;

ROUTINE and RESEARCH LABORATORIES, who desire information on instruments.

Information Section

Correspondence from instrument users and others pertaining to or relative to instruments

THIS section invites correspondence from instrument users and others relative to questions pertaining to instruments. If our own editorial staff should feel that any question submitted cannot be readily answered, we will obtain the necessary information from some of our collaborators. Thus the greatest experts are at the disposal of our readers in assisting them in the solution of their instrument problems.

Names and addresses of manufacturers of instruments will be furnished on special request. Inquiries pertaining to sources of supply should be addressed in writing to our Information Section. Such inquiries will be answered promptly by mail.

Inquiries regarding instrument problems will be answered by publication in this special "Information Section" of INSTRUMENTS. We feel that other besides the inquirers may be interested in the same or similar problems, and in this way all of our readers will obtain the benefit of the information furnished.

New Instruments

Recently Developed by Instrument Manufacturers

Wilson-Maeulen Open Scale Recorder

(Wilson-Maeulen Company)

RECORDERS calibrated for high temperature operations, must usually be expressed on the usual width of chart. This crowds the calibration lines closer together than the lines on a chart of lower temperature range. Manifestly to start a high temperature scale at a temperature above 1000°F instead of at 75° would permit each division to represent fewer degrees. The spreading of the upper half of the range over the full width of chart is accomplished by an entirely different method than heretofore used.

The open scale is accomplished by an electrically controlled zero point and provides in effect a scale of more than twice the former width, and without sacrifice of instrument accuracy. A Wheatstone bridge circuit is employed to electrically control the zero by definitely counteracting a definite part of thermocouple voltage equivalent to the voltage of the couple at the temperature chosen as zero.

To illustrate, on a 1600°F to 3000° F instrument the mechanical (or open circuit) zero of the galvanometer is set at the center of the scale (2300°F) and the electrical zero control is adjusted to equal the thermocouple voltage at 2300°F, so that the galvanometer is in balance at that temperature and deflects plus and minus from that point, according to thermocouple temperature.

The recorder may have automatic cold junction compensation for use with compensator leads and then the scale spreading and cold junction correction are accomplished by a single electrical system which is a combination of the Wheatstone bridge and automatic electric cold junction compensator. The combination circuit is checked by comparison with a standard cell in the recorder by using a convenient check switch, and the accuracy of the electrical zero control is established by rheostat adjustment of the dry cell current until the galvanometer shows no deflection from the established control line.

Not only does this design provide a more open scale equivalent to more than twice the former width, without sacrificing in any respect the

accuracy of measurement, but it greatly enhances and improves the accuracy of the temperature measurement in the following manner.

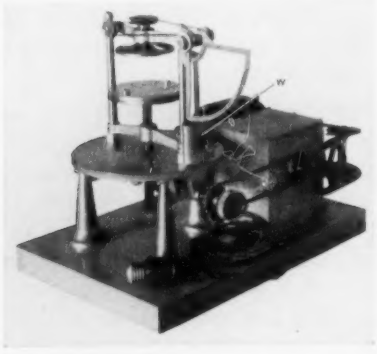
Errors due to incorrect total circuit resistance, called resistance errors (brought about by line resistance differences or temperature co-efficient), are a percentage of only the deflection of the galvanometer, and not a percentage of the scale reading, unless as in a scale starting at 0° the entire scale reading represents galvanometer deflection. With the lower part of the scale eliminated and having selected a zero point at the center of the chart, close to the temperature being recorded, galvanometer deflection is never more than a few hundred degrees, and resistance errors, if any, are a percentage of the few hundreds degrees deflection, and not a percentage of the many hundred degrees of scale reading.

Thus the opening of the scale of the instrument loses none of the accuracy of the normal recorder, but it does limit the use of the open scale instrument to application where the omitted low portion of the scale is not needed. For operations of consistent and continual high temperature, the instrument provides an extra wide scale and a very high order of accuracy of temperature measurement.

—— ——::——

The Emley Plasticimeter

THIS instrument (manufactured by the American Instrument Company), was designed to determine the plasticity of hydrated lime, the test being carried out as described in Bureau of Standards Circular No. 204.



The instrument consists essentially of a rotating table which raises while it rotates. The vertical rise for one complete revolution of the table is 1/13 of an inch and is accomplished in 6 minutes and 40 seconds. The pat of the material which has been previously set on an absorption plate, which in turn rides on the rotary table, is brought into contact with an upper disc which is free to rotate. This disc has a tap to it, a series of cords, which as it rotates raises the weight "w."

The Cambridge Recording Accelerometer

(Cambridge Instrument Co.)

THE Cambridge recording accelerometer shown in the accompanying illustrations can be used for recording either horizontal or vertical accelerations, depending upon the position in which it is placed relative to the direction of the movement being investigated. A plan of the instrument, as placed for recording vertical accelerations, is shown diagrammatically in Fig. 2. The mass M is supported by two flat steel strips, H and H_1, and is connected by means of an additional steel strip N to a member O moving on knife-edges K and K_1. This member carries a flat strip of aluminum L, the extremity of which is free to move between the poles of a magnet P. Fixed to the aluminum strip L is the stylus Q. Any movement, therefore, of the mass moves the stylus across the celluloid film A which is made to pass round the roller T by means of a clock-work mechanism not shown. The speed of travel of the film may be varied from approximately 3 to 20 mm. per second. The eddy currents set up by the movement of the aluminum strip between the poles of the magnet critically damp the movement. With the standard spring, the natural period of the whole system is approximately 0.025 seconds. With this period the sensitivity is approximately 1 mm. on the actual record for an acceleration equal to "g" (32.2 ft. per sec.); the record can be measured to an accuracy of 1/100 of this value. Other sensitivities may also be obtained, the period being correspondingly altered. The pressure of the stylus on the film can be varied by means of the screw C. An electromagnetic marking mechanism, not shown in the diagram, is fitted so that a time scale, generally tenths of a second, can be marked on the film by means of a second stylus marking on the back of the film. It is thus possible for the

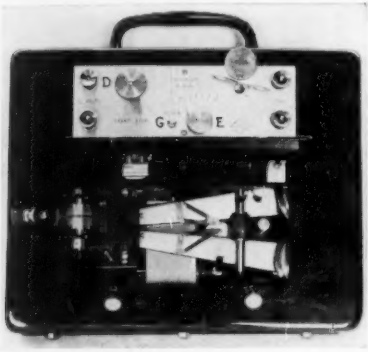


Fig. 1—Double Accelerometer.

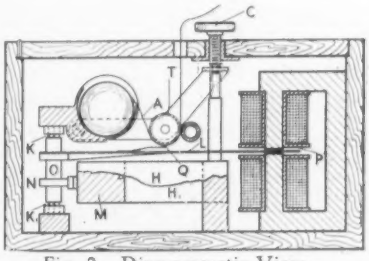


Fig. 2—Diagrammatic View.

stylus making the record of accelerations to pass over the whole of its range without fouling the time marking stylus.

The complete mechanism is enclosed within a compact case. On the front of the case are carried the various switches for controlling the mechanism, together with the terminals for connection to the time-marker and to the 12-volt battery for the damping electromagnet. The clockwork mechanism is started or stopped by the switch D, but it can also be started independently by depressing the push button G when it is only desired to run a short length of film for calibrating purposes. The speed of the film is adjusted by means of the lever E. Three toes are provided on each of 2 adjacent sides of the base, enabling the instrument to be placed on either its long base, for recording vertical accelerations, or its short base, for recording horizontal accelerations.

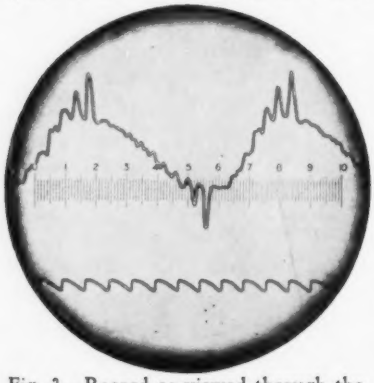


Fig. 3—Record as viewed through the microscope.

Accelerometers for making two simultaneous records of accelerations in two planes at right angles are also available. Fig. 1 shows the accelerometer for this purpose.

In aerodynamic research work, it is frequently desirable to obtain permanent records of the speeds attained during a flight, and also to record simultaneously the acceleration along some axis of the plane. The instrument designed for this purpose comprises a recording accelerometer and an air speed recorder mounted in the same case. The accelerometer may be used for recording the component of the acceleration in any direction in relation to the plane. The air speed is measured by a pitot tube of the standard aircraft pattern.

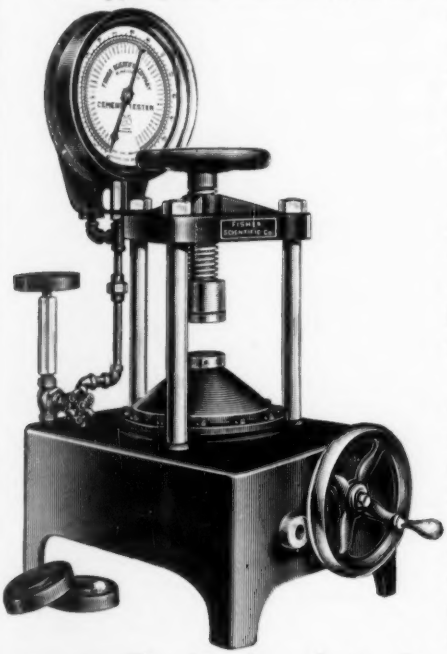
The principal novel feature of the design of this instrument is in the method of recording. The records are obtained by the action of a moving stylus upon transparent celluloid film. The pressure on the stylus is very light and the celluloid flows plastically under the rounded point of the stylus, the line produced having such optical characteristics as to render any points on an enlarged image of the diagram readable to a high degree of accuracy. A wide range of accelerations can thus be successfully recorded. The moving parts of the instrument are small and arranged to move through small distances, so that accelerations of considerable magnitude, or vibrations of high frequency, are recorded accurately and undisturbed by instrumental inertia effects. The stylus-on-celluloid method of recording has also the advantage of durability, in that the record cannot fade, and is impervious to oil or water.

Fisher Compression Test Machine

(Fisher Scientific Co.)

THE machine is a small hydraulic press in which the pressure is generated in the base, by means of a ram operated by the handwheel in front. The pressure thus generated is exerted on a large piston connected to the lower platen and thus the pressure is applied to the test piece.

The upper platen which engages the test piece, is connected by a self-centering ball-and-socket joint which equalizes the pressure over the entire surface of the test piece. The upper platen is raised and lowered by the handwheel at the top.



The gauge indicates the pressure applied and a gauge checker is directly connected so that the gauge readings can be conveniently checked at any time.

This machine permits the entire range of pressure to be applied uniformly by means of the handwheel, without any exertion on the part of the operator. The rate of application of the pressure is easily controlled by the operator. In this machine the usual objections to the hydraulic press type are overcome. The piston has a floating fit and is covered by a rubber diaphragm. The pressure is exerted on the rubber diaphragm and the higher the pressure the more tightly it is sealed against leakage. This diaphragm is easily replaced.

The direct-reading gauge is most convenient for measuring the pressure and for controlling its application because the pressure is indicated at all times and the approach of the breaking point is readily observed. It should be borne in mind that the pressure shown by the gauge is the total pressure exerted on the large piston. The gauge itself is not subjected to this same total pressure but only a fraction thereof; in reality only one-fiftieth. Any question as to the correctness of the gauge readings is eliminated by checking it with the gauge checker permanently connected to the machine. The gauge checker is operated by applying the

weights supplied, and opening the valve which connects it to the hydraulic system.

The ball-and-socket joint of the upper platen which engages the test piece, adjusts itself to the upper surface of the test piece after which the pressure is exerted evenly over the entire surface.

The entire machine weighs about 375 pounds. It can be transported from place to place and it occupies only a small space when used in the laboratory. Dimensions are 17 inches wide, 30 inches deep and 40 inches high.

———::———

The Tag-Isom Blending Calculator

(Tagliabue Manufacturing Co.)

THE Tag-Isom Blending Calculator is a slide rule for solving blending problems either on the basis of viscosity or gravity. It was designed by a practical oil man after years of experiments with samples of different oils, the viscosities and gravities of which were accurately known. From this data curves were drawn and the master scale plotted.

Knowing proportions and properties of heavier and lighter oils, one can instantly determine the viscosity (or gravity) of the blend. Knowing the viscosities (or gravities) of two oils and the viscosity (or gravity) of the desired blend, one can instantly determine the correct proportion, etc. This ingenious device will not only do more than charts or formulae but it will do it quicker, more accurately and with much less effort on the part of the operator.

The calculator is about 13½" long and 6" wide, substantially constructed, and easily carried.

One side is used for the gravity calculations, both A.P.I. and Specific Gravity scales—the latter a greater convenience when blends of foreign products are involved. On the other side are the viscosity scales, one for oils at 100°F and the other for oils at 210°F.

The features of the Tag-Isom Blending Calculator:

1. A simple rule takes the place of charts or empirical formulae.
2. Viscosity scales for oil at either 100°F or 210° F.
3. Both A.P.I. and Specific Gravity scales.
4. Both gravity and viscosity scales based on scientific experiments.
5. Scales are open and more easily read than any chart, making results more accurate.
6. Any blending problem can be worked out in a few seconds.
7. Handy to carry, easy to operate, no parts to wear out, no charts to replace.

Fig. 1—This side is used for gravity calculations.

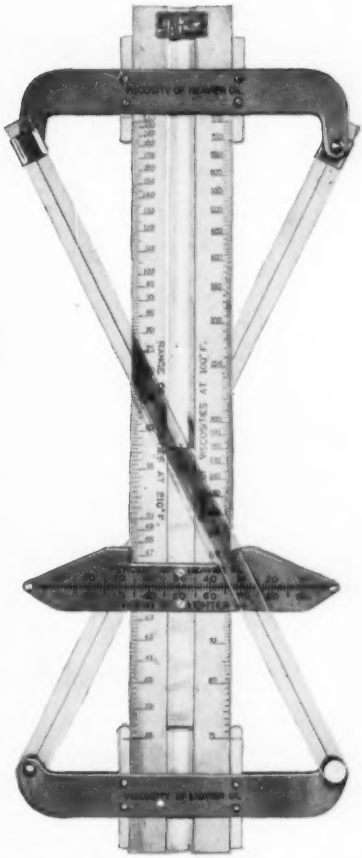


Fig. 2—Viscosity scales for oils at 100°F and 210°F.

It is common experience that next to possessing information the ideal desideration is to know where to find it. This is especially true at present when the vast amount of information probably available on almost any subject is so great as to lie beyond the capacity of an individual. The problem usually is to know where to find what is wanted.

The world-wide demand for information of all kinds has grown so rapidly that one is often at his wit's end to know where to look for it.

If you are looking for instrument information—you will find it in Instruments.

The Scientific Instrument of To-day—
The Industrial Instrument of To-morrow

IT is agreed that instruments are becoming more universally used from day to day. Now the problem is —how can we most readily obtain this profitable business?

THE layman must be EDUCATED to the thousand and one uses of instruments. He must be MADE to appreciate the unusual possibilities coupled with their use in his plant.

SALESMEN are required that will constantly bring home to him the same facts in new and interesting ways. Only constant "hammering" will make him realize the importance of the use of instruments. Time is necessary for such an achievement.

The monthly issues of

INSTRUMENTS

INDUSTRIAL - SCIENTIFIC

are your salesmen

Received each month they furnish the proper background for the efforts of your representatives.

Current Literature Review

Abstracts on instruments of interest to instrument readers

During the year 1928 the following periodicals will be searched regularly for information and articles on instruments.

*The references marked with an asterisk will be used only if the original periodical is not available.

The review will also cover books published on the subject of instruments.

Abbreviations used in INSTRUMENTS	Full Title of Periodical	Place of Publication
Abs. Bull.*	Abstract Bulletin, Research Laboratory	General Electric Co., Nela Park Cleveland, Ohio.
A. E. G. Mitt.	A.E.G. Mitteilungen	Berlin NW 40, Friedrich Karl-Ufer 2-4, Germany
Amer. Gas. Jl.	American Gas Journal	53 Park Place, New York, N.Y.
Amer. Gas. Ass.	American Gas Association Monthly	342 Madison Ave., New York, N.Y.
Amer. Jl. Sci.	American Journal of Science	New Haven, Conn.
Amer. Mach.	American Machinist	10 Ave. at 36 St., New York, N.Y.
Analyst	Analyst	W. Heffer & Sons, Cambridge, Eng.
Ann. Chemie	Annalen der Chemie	Verlag Chemie, Berlin, Germany
Ann. Physik	Annalen der Physik	Verlag A. Barth, Leipzig, Germany
Ann. Chimie	Annales de Chimie	120 Boulevard St. Germain, Paris, France
Ann. Mines	Annales de Mines	Dunod, Paris 92, Rue Bonaparte, France
Ann. Physique	Annales de Physique	120 Boulevard St. Germain, Paris France
Arch. Elekt.	Archiv fuer Electrotechnik	J. Springer, Berlin, Germany
Arch. Waermew.	Archiv fuer Waermewirtschaft und Dampfkesselwesen	V.D.I. Verlag, Berlin NW 7, Dorotheenstr. 40, Germany
Astro. Jl.	Astrophysical Journal	Univ. of Chicago Press, Chicago
Auto. Abs.*	Automotive Abstracts	Ohio State Univ., Columbus, Ohio
Auto. Ind.	Automotive Industries	56 & Chestnut Sts., Phila., Pa.
Aviation	Aviation	250 W. 57 St., New York, N.Y.
Bell Jl.	Bell System Technical Journal	195 Broadway, New York, N.Y.
Bell Quarterly	Bell Telephone Quarterly	Amer. Telephone & Telegraph Co., New York, N.Y.
Ber. d. Chem. Ges.	Berichte der Deutchen Chemischen Gesellschaft	Berlin W 10, Corneliusstr. 3, Germany
Ber. Fachauesch.	Berichte der Fachausschusse des Vereins deutscher Eisenhuettenleute	Duesseldorf, Schliesfach 664, Germany
Beton Eisen	Beton und Eisen	Berlin, W 8, Wilhelmstr., Germany
Bibliographia Chimica*	Bibliographia Chimica	Verlag Chemie, Leipzig, Bosestr. 2, Germany
Bibliographia Technica*	Bibliographia Technica	V.D.I. Verlag, Berlin SW 19, Beuthstr. 7, Germany
Brass World	Brass World & Plater's Guide	153 Waverly Place, New York, N.Y.
Br. Cl. Record	Brick and Clay Record	407 S. Dearborn St., Chicago, Ill.
Brit. Chem. Abs.*	British Chemical Abstracts Bureau of Chemical Abstracts	Central House 46, Finsbury Sq., London, E.C. 2, England
Bull. Abs.*	Bulletin of Abstracts	American Gas Association, Easton, Pa.
Bull. A.S.T.M.	Bulletin of the American Society for Testing Materials	1315 Spruce St., Philadelphia, Pa.
Bull. Bur. Mines	Bulletin of the Bureau of Mines	Bureau of Mines, Washington, D.C.
Bull. Brit. C.I. Res. Ass.	Bulletin of the British Cast Iron Research Association	24 St. Paul's Square, Birmingham, England
Bull. Soc. Francaise Elect.	Bulletin de la Societe Francaise des Electriciens	12 Rue de Stael, Paris 15e France
Bull. Taylor Soc.	Bulletin of the Taylor Society	29 West 39 St., New York, N.Y.
Can. Chem.	Canadian Chemistry and Metallurgy	40 Richmond St., West, Toronto 2, Ont., Canada
Can. Eng.	Canadian Engineer	62 Church St., Toronto, Canada

Abbreviations used in INSTRUMENTS	Full Title of Periodical	Place of Publication
Can. Min.	Canadian Mining Journal	Garden City Press, Gardenvale, Quebec, Canada
Ceramic Age	Ceramic Age	170 Roseville Ave.,Newark, N.J.
Ceramic Ind.	Ceramic Industry	407 So. Dearborn St., Chicago, Ill.
Chal. Ind.	Chaleur et Industrie	5 Rue Michel-Ange, Paris, France
Chem. Abs.*	Chemical Abstracts	American Chemical Society, Easton, Pa.
Chem. Age	Chemical Age	154 Fleet St., London, E.C.4, England
Chem. & Met.	Chemical & Metallurgical Engineering	10 Ave. at 36 St., New York, N.Y.
Chem. News	Chemical News & Journal of Industrial Science	Merton House, Salisbury Square, London, E.C.4, England
Chem. Rev.*	Chemical Reviews	Williams & Wilkins Co., Baltimore, Md.
Chem.-Zg.	Chemiker-Zeitung	Verlag der Chemiker-Zeitung, Cothen (Anhalt) Germany
Chem. Zentralbl.	Chemisches Zentralblatt	Verlag Chemie, Corneliusstr. 3, Berlin W 10, Germany
Chem. Ind.	Chemistry and Industry	46 Finsbury Square, London E.C. 2, England
Chim. Ind.	Chimie & Industrie	49 Rue des Mathurins, Paris, France
Circ. Bur. Stds.	Circular of the Bureau of Standards	Bureau of Standards, Washington, D.C.
Clay Worker	The Clay Worker	T. A. Randall & Co., Indianapolis, Ind.
Coll. Guard.	Colliery Guardian & Journal of the Coal & Iron Trades	31 Furnival St., Holborn, London E.C. 4, England
Combustion	Combustion	43 Broad St., New York, N.Y.
Compr. Air Mag.	Compressed Air Magazine	Bowling Green Bldg., 11 Broadway, New York, N.Y.
Comptes rendus	Comptes rendus hebdomadaires des seances de l'Academie des Sciences	Gauthier-Villars & Cie, 55 Iuai des Grands-Augustins, Paris, France
Concrete	Concrete	139 North Clark St., Chicago, Ill.
Con. & Cons. Engg.	Concrete & Constructional Engineering	20 Dartmouth St., Westminster SW 1, London, England
Dingler	Dinglers Polytechnisches Journal	Regensburger Str. 12a, Berlin W 50, Germany
Ed. Poids & Mesures	Editions de Chambre Centrale des poids et mesures	Mejdounarody pr. 19, Leningrad, Russia
Elect. Jl.	The Electric Journal	Keenan Bldg., Pittsburgh, Pa.
Elect. Light	Electric Light & Power	360 N. Michigan Ave., Chicago, Ill.
Elect. Rail Jl.	Electric Railway Journal	10 Ave. at 36 St., New York, N.Y.
El. Record	Electrical Record	114 Liberty St., New York, N.Y.
El. Rev.	Electrical Review	4 Ludgate Hill, London E.C. 4, England
El. West	Electrical West	883 Mission St., San Francisco, Calif.
El. World	Electrical World	10 Ave. at 36 St., New York, N.Y.
Electrician	Electrician	8 Bouverie St., London, E.C. 4, England
Electrician	L'Electrien	92 Rue Bonaparte, Paris 6, France
E. u. M. Wien	Elektrotechnik und Maschinenbau	Theobaldgasse 12, Vienna VI, Austria
E. T. Z.	Elektrotechnische Zeitschrift	Linkstr. 23/24, Berlin W 9, Germany
Eng.	The Engineer	33 Norfolk St., London, W.C. 2, England
Engs. & Engg.	Engineers & Engineering	Engineers Club of Philadelphia, 1317 Spruce St., Philadelphia, Pa.
Engg.	Engineering	35 Bedford St., London W.C. 2, England
Engg. Boiler House Rev.	Engineering & Boiler House Review	13 Fisher St., Southampton Row, London W.C. 1, England
Engg. Jl.	Engineering Journal	Engineering Institute of Canada, 176 Mansfield St., Montreal, Canada
Engg. News-Rec.	Engineering News Record	10 Ave. at 36 St., New York, N.Y.
Engg. Min. Jl.	Engineering & Mining Journal Press	10 Ave. at 36 St., New York, N.Y.
Engg. Progress	Engineering Progress	Progressus, Krausenstr. 38/39, Berlin SW 19, Germany

Abbreviations used in INSTRUMENTS	Full Title of Periodical	Place of Publication
Factory	Factory	Shaw Co., Cass, Huron & Erie Sts., Chicago, Ill.
Feuerungstechn.	Feuerungstechnik	Otto Spamer, Heinrichstr. 9, Leipzig C 1, Germany
Fonderie Mod.	La Fondernie Moderne	Association Technique de Fonderie 15 Rue Bleue, Paris 9e, France
Foundry	Foundry	Penton Publishing Co., Cleveland, Ohio
Foundry Trade Jl.	Foundry Trade Journal	49 Wellington St., Strand, London W.C. 2, England
Fuel Sc. Pr.	Fuel in Science & Practice	30 Furnival St., London E.C. 4, England
Gas Age-Record	Gas Age-Record	52 Vanderbilt Ave., New York, N.Y.
Gas. Ind.	Gas Industry	Periodicals Publishing Co., Buffalo, N.Y.
Gas. Jl.	Gas Journal	11 Bolt Court, Fleet St., London E.C. 4, England
Gas Wasserfach	Das Gas-und Wasserfach	R. Oldenbourg, Gluckstr. 8, Munchen, Germany
Gl. Appar	Glas und Apparat	R. Wagner & Sohn, Weimar, Germany
Gas World	Gas World	154 Fleet St., London E.C. 4, England
G. E. Rev.	General Electric Review	General Electric Co., Schenectady, N.Y.
Genie Civil	Le Genie Civil	6 Rue de la Chaussee-d'Antin, Paris (9e) France
Giess-Zg.	Giesserei-Zeitung	Jerusalemer Str. 46/49, Berlin SW 19, Germany
Giorn. Chim. Ind. App.	Giornale di Chimica Industriale ed Applicata	Via S. Poolo 10, Milano (103) Italy
Gl. Ind.	Glas Industrie	Spaeth & Linde, Genthiner Str. 42, Berlin Y 10, Germany
Glaser	Glasers Annalen	Lindenstrasse 80, Berlin SW, Germany
Glashuette	Glashuette	Spaeth & Linde, Genthiner Str. 42 Berlin Y 10, Germany
Glass	Glass	65 Victoria St., London SW 1, England
Glass Ind.	Glass Industry	19 Liberty St., New York, N.Y.
Glueckauf	Glueckauf	Friedrichstr. 2, Essen, Germany
Heat. Ventil. Mag.	Heating & Ventilating Magazine	1123 Broadway, New York, N.Y.
Ice. & Ref.	Ice & Refrigeration	5707 West Lake St., Chicago, Ill.
Il. Eng.	Illuminating Engineer	32 Victoria St., London SW 1, England
Ind. Chem.	Industrial Chemist & Chemical Manufacturer	33 Tothill St., Westminster, London SW 1, England
Ind. Eng.	Industrial Engineer	Old Colony Bldg., Chicago, Ill.
Ind. Engg. Chem.	Industrial & Engineering Chemistry	1709 G St., N.W., Washington, D.C.
Ind. Power	Industrial Power	608 So. Dearborn St., Chicago, Ill.
Iron Age	The Iron Age	239 West 39 St., New York, N.Y.
Ir. & St. Canada	Iron & Steel of Canada	Garden City Press, Gardenvale, Que., Canada
Ir. Coal Tr. Rev.	Iron and Coal Trades Review	49 Wellington St., Strand, London WC 2, England
Ironmonger	Ironmonger	42 Cannon St., London EC 4, England
Ir. St. Eng.	Iron & Steel Engineer	1706 Empire Bldg., Pittsburgh, Pa.
Ir. Tr. Rev.	Iron Trade Review	Penton Publishing Co., Cleveland, Ohio
Jl. Amer. Ceram. Soc.	Journal of the American Ceramic Society	2525 N. High St., Columbus, Ohio
Jl. Amer. Chem. Soc.	Journal of the American Chemical Society	Easton, Pa.
Jl. Amer. Soc. Heat. Ventil.	Journal of the American Society of Heating & Ventilating Engineers	20 & North Hampton Sts., Easton, Pa.
Jl. Amer. Soc. Naval Engrs.	Journal of American Society of Naval Engineers	Washington, D.C.
Jl. Amer. Soc. Ref. Engrs.	Journal of the American Society of Refrigerating Engineers	37 West 39 St., New York, N.Y.

Abbreviations used in INSTRUMENTS	Full Title of Periodical	Place of Publication
Jl. Amer. Waterw. Ass.	Journal of the American Waterworks Association	Mt. Royal & Guilford Ave., Baltimore, Md.
Jl. Amer. Weld. Soc.	Journal of the American Welding Society	33 West 39 St., New York, N.Y.
Jl. App. Phys.	The Journal of Applied Physics	Moscow, Russia
Jl. Chem. Soc.	Journal of the Chemical Society	33 Paternoster Row, London EC 4, England
Jl. Chem. Met. Min. Soc. So. Africa	Journal of the Chemical, Metallurgical & Mining Society of South Africa	100 Fox St., Johannesburg, South Africa
Jl. Chim. Phys.	Journal de Chimie Physique	49 Boulevard Saint-Michel Paris (Ve), France
Jl. Engg. Inst. Can.	Journal of the Engineering Institute of Canada	176 Mansfield St., Montreal, Can.
Jl. Franklin Inst.	Journal of the Franklin Institute	15 South 7 St., Philadelphia, Pa.
Jl. Geology	Journal of Geology	Univ. of Chicago Press, Chicago, Ill.
Jl. Inst. Elect. Engrs.	Journal of the Institution of Electrical Engineers	Savoy Place, Victoria Embankment, London, WC 2, England
Jl. Inst. Pet. Tech.	Journal of the Institution of Petroleum Technologists	Aldine House, Bedford St., Strand, London, WC 2, England
Jl. N. E. Water Wks. Ass.	Journal of the New England Waterworks Association	714 Tremont Temple, Boston, Mass.
Jl. Opt. Soc.	Journal of the Optical Society of America and Review of Scientific Instruments.	Cornell University, Ithaca, N.Y.
Jl. Phys. Chem.	Journal of Physical Chemistry	Baker Laboratory, Ithaca, N.Y.
Jl. Phys. Rad.	Journal de Physique et le Radium	10 Rue Vanquelin, Paris V, France
Jl. Prak. Chemie	Journal fuer Praktische Chemie	J. A. Barth, Salomon Strasse 18b Leipzig, Germany
Jl. Royal Aero Soc.	Journal of the Royal Aeronautical Society	7 Albermarle St., Piccadilly, London W 1, England
Jl. Royal Micro. Soc.	Journal of the Royal Microscopical Society	20 Hanover Square, London W 1, England
Jl. Royal Soc. Arts	Journal of the Royal Society of Arts	York House, Portugal St., London WC 2, England
Jl. Russ. Phys. Chem. Soc.	Journal of the Russian Physico-Chemical Society	Leningrad, Russia
Jl. Scient. Instr.	Journal of the Scientific Instruments	Cambridge Univ. Press, Fetter Lane, London EC 4, England
Jl. S. A. E.	Journal of the Society of Automotive Engineers	29 West 39 St., New York, N.Y.
Jl. Soc. Chem. Ind.	Journal of the Society of Chemical Industry	46 Finsbury Square, London EC 2, England
Jl. Soc. Glass Tech.	Journal of the Society of Glass Technology	The University, Sheffield, England
Jl. Washington Acad. Sci.	Journal of the Washington Academy of Sciences	Mt. Royal & Guilford Ave., Baltimore, Md.
Jl. W. Scot. Ir. & St. Inst.	Journal of the West of Scotland Iron & Steel Institute	T. A. Fraser, 93 Hope St., Glasgow, Scotland
Jl. West. Soc. Engrs.	Journal of the Western Society of Engineers	723 Lake St., Oak Park, Ill.
Liebig's Annalen	Liebig's Annalen der Chemie	C. F. Wentersche Verlagshandlung, Leipzig, Germany
Lond. Phil. Mag.	London, Edinburgh & Dublin Philosophical Magazine	Taylor & Francis, Red Lion Court, Fleet St., London, England
Machinery	Machinery	140 Lafayette St., New York, N.Y.
Management	Management	58 Washington St., Chicago, Ill.
Mfg. Ind.	Manufacturing Industries	Ronald Press Co., Federal & 19th Sts., Camden, N. J.
Mar. Engg.	Marine Engineering & Shipping Age	Woolworth Bldg., New York, N.Y.
Masch.-B.	Maschinenbau	Dorotheenstr. 40, Berlin NW 7, Germany
Mech. Engg.	Mechanical Engineering	29 West 39 St., New York, N.Y.
Mem. Compte Rendu	Memoires et Compte Rendu des Travaux de la Societe des Ingenieurs Civils de France	19 Rue Blanche, Paris (9e) France
Messtechnik	Messtechnik	Wilhelm Knapp, Muhlweg 19, Halle (Saale), Germany
Met. Ind. (N.Y.)	Metal Industry, New York	99 John St., New York, N.Y.
Met. Ind. (Lond.)	Metal Industry and the Iron Foundry	22 Henrietta St., London WC 2, England
Metal Erz	Metall und Erz	Muhlweg 19, Halle (Saale), Germany

Abbreviations used in INSTRUMENTS	Full Title of Periodical	Place of Publication
Metallurgist	The Metallurgist, Supplement to the "Engineer"	33 Norfold St., Strand, London WC 2, England
Military Eng.	Military Engineer	Society of American Military Engineers, Mills Bldg., Washington, D.C.
Min. Met.	Mining and Metallurgy	29 West 39 St., New York, N.Y.
Min. Con. Jl.	Mining Congress Journal	American Mining Congress, Washington, D.C.
Min. Mag.	Mining Magazine	Salisbury House, London EC 2, England
Mett. K.W. Inst. Eisenforsch	Mitteilungen aus dem Kaiser Wilhelm Institute fuer Eisenforschung	Schliessfach 664, Duesseldorf, Germany
Mitt. Materialpruef.	Mitteilungen aus dem Materialpruefungsamt Kaiser-Wilhelm Institute fuer Metallforschung	Julius Springer, Linkstr. 23/24, Berlin W9, Germany
Mont. Rdsch.	Montanistische Rundshau, Zeitschrift fuer Berg und Huettenwesen	Courbierestr. 3, Berlin, Germany
Monatsch. Chem.	Monatshefte fuer Chemie	Holder-Pichler-Tempsky, Vienna, Austria
Motor Age	Motor Age	5 So. Wabash Ave., Chicago, Ill.
Nat. Eng.	National Engineer	407 So. Dearborn St., Chicago, Ill.
Nat. Gas	Natural Gas	9 W. 4 St., Cincinnati, Ohio
Ohio Jl. So.	Ohio Journal of Science	Ohio State Univ., Columbus, Ohio
Oil Age	Oil Age	Insurance Exchange Bldg., Los Angeles, Calif.
Oil Eng. Power	Oil Engine Power	220 West 42 St., New York, N.Y.
Paper Ind.	Paper Industry	356 Monadnock Bldg., Chicago
Paper Tr. Jl.	Paper Trade Journal	10 East 39 St., New York, N.Y.
Petroleum	Petroleum	Courbierestr. 3, Berlin W 62, Germany
Philippine Jl. Sc.	Philippine Journal of Science	Bureau of Printing, Manila, P. I.
Phys. Rev.	Physical Review	American Physical Society, 1500 University Ave., S.E. Minneapolis, Minn.
Phys. Ber.	Physikalisch Berichte	Vieweg & Sohn, Vor der Burg 18, Friedr., Braunschweig, Germany
Phys. Zeits.	Physikalische Zeitschrift	Konigstr. 2, s. Hirzel, Leipzig, Germany
Pop. Ast.	Popular Astronomy	Goodsell Observatory of Carleton College, Northfield, Minn.
Pop. Sc. Mon.	Popular Science Monthly	250 Fourth Ave., New York, N.Y.
Power	Power	10 Ave. at 36 St., New York, N.Y.
Power Pl. Engg.	Power Plant Engineering	537 So. Dearborn St., Chicago, Ill.
Proc. A.S.C.E.	Proceedings of the American Society of Civil Engineers	33 West 39 St., New York, N.Y.
Proc. A.S.T.M.	Proceedings of the American Society for Testing Materials	1315 Spruce St., Philadelphia, Pa.
Proc. Cleveland Inst. Engrs.	Proceedings of the Cleveland Institution of Engineers	Corporation Road, Middlesborough, England
Proc. Engrs. Soc. W. Pa.	Proceedings of the Engineers' Society of Western Pennsylvania	William Penn Hotel, Pittsburgh, Pa.
Proc. Inst. Radio Engrs.	Proceedings of the Institute of Radio Engineers	21 Center St., Middletown, N.Y.
Proc. Inst. Mech. Engrs.	Proceedings of the Institution of Mechanical Engineers	Storey's Gate, St. James' Park, London, SW 1, England
Proc. Nat. Acad. Sc.	Proceedings of the National Academy of Sciences	Harvard School of Public Health, Boston 17, Mass.
Proc. Naval Inst. U.S.	Proceedings Naval Institute of the United States	Annapolis, Maryland
Proc. Phys. Soc. Lond.	Proceedings of the Physical Society of London	3-9 Dane St., High Holborn, London WC 1, England
Pub. Ontario Depart. Mines	Publications of the Ontario Department of Mines	Toronto, Canada
Railway Age	Railway Age	Woolworth Bldg., New York, N.Y.
Rail. Mech. Engr.	Railway Mechanical Engineer	Woolworth Bldg., New York, N.Y.
Rail. Signal.	Railway Signaling	608 So. Dearborn St., Chicago, Ill.
Rec. Travaux Chimiques	Recuel des Travaux Chimiques des Pays-Bas	Soc. Anon. D'Editions Scientifiques D. B. Centen, Amsterdam, Holland
Repr. Circ. Ser. Nat. Res. Council	Reprint and Circular Series of the National Research Council	1701 Massachusetts Ave., Washington, D.C.
Rev. Fond. Mod.	La Revue de Fonderie Moderne	15 Rue Bleue, Paris (9e), France
Rev. Gen. Elect.	Revue Generale de l'Electricite	12 Place de Laborde, Paris 8, France
Rev. Gen. Sc. Pures.	Revue General des Sciences Pures et Appliquees	8 Place de L'Oden, Paris (6e), France

Abbreviations used in INSTRUMENTS	Full Title of Periodical	Place of Publication
Rev. Met. Mem. Extr.	Revue de Metallurgie Memoires Extraits	5 Cite Pigalle, Paris (9e), France
Rev. Univ. Mines	Revue Universelle des Mines, de la Metallurgie, des Travaux Publico, des Sciences et des Arts Appliques a l'Industrie	16 Quai des Etats-Unis, Liege, Belgium
Rock Products	Rocks Products	542 S. Dearborn St., Chicago, Ill.
Science	Science	Science Press, Grand Central Terminal, New York, N.Y.
Science Abstracts*	Science Abstracts Section A, Physics Section B, Electrical Engineering	Spon & Chamberlain, 120 Liberty St., New York, N.Y.
Science Progress	Science Progress	John Murray, Albemarle St. W, London, England
Science Reports	Science Reports of Tohoku Imperial University	Maruzen Co., Ltd., Tokyo and Sendai, Japan
Scientia	Scientia	Nicola Zanichelli, Bologna, Italy
Sc. American	Scientific American	24 W. 40 St., New York, N.Y.
Sc. Monthly	Scientific Monthly	Grand Central Terminal, New York, N.Y.
Sc. Papers B. of S.	Scientific Papers of the Bureau of Standards	Washington, D.C.
Sel. Engg. Papers	Selected Engineering Papers	Institution of Civil Engineers, Great George St., Westminster S.W. 1, London, England
Siemens Zeits.	Siemens-Zeitschrift	Siemensstadt bei Berlin, Germany
Sibley Jl.	Sibley Journal of Engineering	Cornell Univ., Ithaca, N.Y.
So. Power Jl.	Southern Power Journal	
Sprechsaal	Sprechsaal	Muller & Schmidt, Coburg, Germany
St. u. E.	Stahl und Eisen	Schliessfach 664, Duesseldorf, Germany
T.P.B. of M.	Technical Papers, Bureau of Mines	Washington, D.C.
T.P.B. of S.	Technologic Papers, Bureau of Standards	Washington, D.C.
Tech. Rev.	Technology Review	Mass. Inst. of Tech., Cambridge, Mass.
Techn. Zeits.*	Technische Zeitschriftenshau	Dorotheenstr. 40, Berlin NW 7, Germany
Telephony	Telephony	608 So. Dearborn St., Chicago, Ill.
Trans. Electrochem. Soc.	Transactions of the Amerizan Electrochemical Society	Columbia Univ., New York
Trans. A.M. Soc.	Transactions of the American Microscopical Society	Urbana, Ill.
Trans. A.S.S.T.	Transactions of the American Society for Steel Treating	7016 Prospect Ave., Cleveland, Ohio
Trans. Faraday	Transactions of the Faraday Society	33 Paternoster Row, London E.C. England
Trans. I. E. S.	Transactions of the Illuminating Engineering Society	29 W. 39 St., New York, N.Y.
Trans. I. M. E.	Transactions of the Institution of Mining Engineers	Cleveland House 225, City Road, London E.C. 1, England
Wasser & Gas	Wasser und Gas	Hertelstrasse 5, Berlin-Friedenau, Germany
Weld. Eng.	Welding Engineer	608 So. Dearborn St., Chicago, Ill.
Werkst. Techn.	Werkstattstechnik	Julius Springer, Linkstr. 23/24, Berlin W 9, Germany
Zs. Angur. Chem.	Zeitschrift fuer angewandte Chemic	Corneliusstr. 3, Berlin W 10, Germany
Zs. Feinmech.	Zeitschrift fuer Feinmechanik und Praezision	Gebr. Richters, Erfurt, Germany
Zs. Instrument.	Zeitschrift fuer Instrumentenkunde	Julius Springer, Linkstr. 23/24, Berlin W 9, Germany
Zs. Metallk.	Zeitschrift fuer Metallkunde	Dorotheenstr. 40, Berlin NW 7, Germany
Zs. Oest. Ing. V.	Zeitschrift des Oesterreichischen Ingenieur-und Architekten Vereines	Seilerstatte 24, Wien I, Austria
Zs. phys. Chem.	Zeitschrift fuer Physikalische Chemie	Markgrafenstr. 4, Leipzig, Germany
Zs. Phys.	Zeitschrift fuer Physik	Julius Springer, Linkstr. 23/24, Berlin W 9, Germany
Zs. techn. Phys.	Zeitschrift fuer technische Physik	Dorrienstr. 16, Leipzig, Germany
V.D.I. Zeits	Zeitschrift des Vereins deutscher Ingenieure	Beuthstr. 7, Berlin SW 19, Germany
Zs. Vermess.	Zeitschrift fuer Vermessungswessen	Postfach 147, Stuttgart, Germany

Review of Recent Patents

Printed copies may be obtained at the cost of 10 cents by addressing the Commissioner of Patents, Washington, D. C.

BEGINNING with the next issue of Instruments, the Patent Review will cover the following patent publications:

1. Official Gazette of the United States Patent Office.
2. Illustrated Official Journal, England.
3. Patent Office Record and Register of Copyrights and Trade Marks, Canada.
4. Patent Office Journal, Wellington, New Zealand.
5. Patentblatt und Auszuege aus den Patent-Schriften, Germany.

Catalogue Library

Check any of the publications you want. Remove the page and send with coupon to INSTRUMENTS. They will be forwarded to you without cost or obligation.

UNDOUBTEDLY the catalogues of a decade or so ago lived up to the strict dictionary definition "a list of things." Today, however, a catalogue is the result of no small effort and expense on the part of the manufacturer, who sets forth the merits of his product in such a manner that the public is made to recognize all its good points. Details of manufacture and operation of the instrument are given in considerable detail. It is a learned mind, indeed, that cannot derive some information from this type of literature. As a matter of fact, few books can be purchased where the information contained therein is more up-to-date than that found in the average catalogue.

In this section will be listed each month the new catalogues published during that time by the various instrument companies, who place such information at the disposal of the editor. Only such catalogues or bulletins should be requested as will be of direct interest to the individual making the request. When the catalogue or bulletin is received it should be carefully filed or afforded the protective accommodation of a book shelf. It will then be available for ready reference at all times and avoid a request for duplicate copies.

Aircraft Instruments

The Pioneer Instrument Co., 754 Lexington Ave., Brooklyn, N. Y., have issued a folder, which contains information on their air distance recorder and speedometer, air speed indicator, compass, fuel level gauge, rate of climb indicator, and turn indicator.

Ammeters

The Bristol Co., Waterbury, Conn., have issued Catalog No. 1502, Ammeter Section, which contains descriptions of the various type ammeters made by them.

Argand Burner

The prices of the Burrell-Argand Burner are listed in Bulletin No. 701 of the Burrell Technical Supply Co., 1704 Fifth Ave., Pittsburgh, Pa.

Automatic Control

Applied to Multiple Effect Evaporators is the title of Catalog No. 937, issued by C. J. Tagliahue Mfg. Co., 18 to 88 Thirty-third Street, Brooklyn, N. Y.

Automatic Control of Combustion

Catalog No. 99 of the Carrick Engineering Company, 538 South Clark St., Chicago, Ill., explains the operation of the master control and floating valve gear by diagrams.

Automatic Temperature Control

Bulletin P.C. 37 issued by the Republic Flow Meters Co., 2240 Diversey Parkway, Chicago, Ill., describes and illustrates their new automatic temperature control.

Bailey Weir Meters

Bulletin No. 61, issued by the Bailey Meter Company, Cleveland, Ohio, explains the principle of operation of the Bailey Weir Meters. By means of diagrams the operation and application is fully described.

Boiler Room Instruments

A booklet entitled "The Chief Engineer Sees the President" has just been issued by the Brown Instrument Co., Wayne & Roberts Aves., Philadelphia, Pa. The booklet is an illustrated lecture, which points out the importance of Boiler Room Instruments.

Brinell Machine

The Fisher Brinell Hardness Tester is the title of a new bulletin published by The Fisher Scientific Company, 711 Forbes St., Pittsburgh, Pa., and is now available for distribution.

Campbell Capacitance Bridge

Is described in List No. 172 of the Cambridge Instrument Company, Inc., 3512 Grand Central Terminal, New York, N. Y. This capacitance bridge is a compact self-contained instrument for quick and accurate measurements of capacitance over the whole range occurring in ordinary practice. The capacitance value is given directly by the multiplied scale reading, without the necessity for any calculation. The Bridge may also be used to measure small self-inductances, mutual inductions up to 150 microhenries, large self-inductances.

Capacitance Bridge

In List No. 172 The Cambridge Instrument Company, Inc., 3512 Grand Central Terminal, New York, N. Y., give the description and operating instruction of the Campbell Capacitance Bridge.

Carrier-Current Telephone Equipment

The General Electric Company, Schenectady, N. Y., have issued bulletin GEA 546, which gives a non-technical explanation of the operation of single-frequency, duplex carrier-current telephone equipment.

CO_2 and CO Indicators and Recorders

C. J. Tagliahue Mfg. Co., 18 to 88 Thirty-third Street, Brooklyn, N. Y., has just issued Tag Mono Catalog No. 942, covering the improved Tag-Mono Gas Analysis Indicator-Recorder. It is of the electrically operated, absorption type and available in the duplex form for CO_2 and CO or single for CO_2 only. Flue gas thermometers are also available for use with this equipment.

CO_2 Meter

The Republic Flow Meters Co., 2240 Diversey Parkway, Chicago, Ill., in their catalog No. CO 38 entitled "CO_2 and Fuel Economy," describe the recorder and its principle of operation.

CO Recorder

Bulletin No. 111 just issued by the Mine Safety Appliance Co., Braddock Ave. & Thomas Blvd., Pittsburgh, Pa., describes their continuous CO Recorder for very low concentrations of carbon monoxide.

Combustion Control

The Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa., have recently published Bulletin No. 660 on metered combustion control.

Combustion Instruments

A leaflet recently issued by The Hays Corporation, Michigan City, Ind., covers their draft gauges, gas analyzers, portable test sets, CO_2 and draft recorders.

Combustion Tubes

Bulletin No. 725 recently issued by The Burrell Technical Supply Co., 1704 Fifth Ave., Pittsburgh, Pa., describes the McDanel Combustion Tubes for carbon determinations in iron and steel laboratories.

Compression Tester for Cement Testing

A bulletin has been published by the Fisher Scientific Company, 711 Forbes St., Pittsburgh, Pa., which has the title "Fisher Cement Testing Apparatus and Accessories."

Constant Temperature Viscosimeter Bath

Is described in a leaflet of the American Instrument Co., 1214-16 D Street, N.W., Washington, D. C.

Delimeter

The delimeter, a device for measuring the pressure used in molding cement mortar briquettes, is the subject of Bulletin No. 305, issued by the American Instrument Company, 1214-16 D Street, N.W., Washington, D. C.

Dilatometer

Bulletin No. 2708 superseding Bulletin No. 2602 has just been issued by The Stanley P. Rockwell Co., 66 Trumbull Street, Hartford, Conn. The principle of the dilatometer is briefly described.

Dissolved Oxygen Recorder

The Cambridge Instrument Company, Inc., 3512 Grand Central Terminal, New York, N. Y., have recently issued List No. 148 on The Cambridge Dissolved Oxygen Recorder for Boiler Feed Water.

Electrical Instruments

A booklet entitled "Electrical Savings in Industry" and dedicated to Industrial Economy, is available for distribution by the Weston Electrical Instrument Co., Newark, N. J.

Electric Tachometers

Pyro electric tachometers are described in an advance notice issued by the Pyrometer Instrument Company, 74 Reade St., New York, N. Y. The generator of the Pyro tachometer operates on a novel application of the electric current generated by revolving its shaft in a magnetic field and rectifying the current in such a manner as to enable it to indicate the number of revolutions per minute.

Extensometer

A sheet describing the Anderson Extensometer has just been issued by Louis C. Eitzen Co., 280 Broadway, New York, N.Y. The instrument is designed for use with either a 2-inch or an 8-inch space bar by which the distance between the two points of attachment of the extensometer, may be accurately set.

Eye Protection Glasses for High Temperature

Carl Zeiss, Inc., 485 Fifth Ave., New York, N. Y., have issued a leaflet on protection glasses for high temperature work. The glass is of special composition and absorbs all the rays injurious to the eye, but still permits good visibility.

Fluid Meters

For steam, water, air and gases in pipes, V-Notch meters, weighing meters and Volumetric meters are described in Bulletin No. 668 issued by The Cochrane Corporation, 17th Street and Allegheny Ave., Philadelphia, Pa.

Fluid Meters for Measuring Steam, Water, Air, Gas and Oil

Electrically operated fluid meters are very completely described in Bulletin No. 131, recently issued by the Bailey Meter Company, Cleveland, Ohio.

Gas Analysis Apparatus

The Burrell Technical Supply Co., 1704 Fifth Ave., Pittsburgh, Pa., have issued a series of bulletins describing Gas Analytic Apparatus. Bulletin No. 750, Standard-Burrell Gas Analysis Apparatus; Bulletin No. 751, Portable Engineer's Model Gas Analysis Apparatus (official U. S. Steel Corp. type); Bulletin No. 752, Gas Analysis Apparatus (Haldane Model); Bulletin No. 753, Gas Analysis Apparatus Model CG., for determining small amounts of impurities in commercial gases such as oxygen, hydrogen, ammonia, carbon dioxide, chlorine, etc.

SEND COUPON FOR LITERATURE DESIRED

INSTRUMENTS PUBLISHING CO., 1117 Wolfendale St., Pittsburgh, Pa.

Please send us, without obligation, the literature checked herewith.

*Company*_____

*Name*_____ *Title*_____

*Address*_____

Ground-Ohmer

This bulletin, issued by Herman H. Sticht & Co., 15 Park Row, New York, N. Y., describes a simple, reliable and universal instrument for measuring ground resistances. Instructions for the operation of the instrument are also given.

Gyro-Compass

Publication No. 17-1609 issued by The Sperry Gyroscope Co., Manhattan Bridge Plaza, Brooklyn, N. Y., explains the operation of the Gyro-Compass and the Gyro-Pilot.

Heat Resisting Alloys

"Calite Alloys" is the title of a bulletin recently issued by the Calorizing Co., Pittsburgh, Pa. This series of heat enduring alloys is available in the form of castings, sheets, shapes and forgings.

Heat Resisting Alloy

Bulletin No. 276 covering general information on Duraloy has recently been issued by The Duraloy Co., 47 Terminal Way, Pittsburgh, Pa.

High Speed Engine Indicator

The American Instrument Co., 1214-16 D Street, N.W., Washington, D. C., have issued a leaflet describing their High Speed Indicator Outfit for accurate pressure measurements in high speed engines.

Industrial Thermometers

The Moto Meter Company, Inc., Long Island City, N. Y., has issued Catalog No. 4 which describes their industrial thermometers.

Magnetic Bridge Permeameter

Is the title of List No. 171 issued by The Cambridge Instrument Company, Inc., 3512 Grand Central Terminal, New York, N. Y. This permeameter enables the magnetisation curve and hysteresis loop to be obtained for any magnetic material. The range of the apparatus covers the measurement of permeability and the determination of the hysteresis loop at high values of the magnetising force.

Micro High Speed Indicator

The Cambridge Micro-Indicator for high-speed engines is not dependent upon optical or photographic methods for the production of the diagrams. They are obtained by direct mechanical means. To prevent overlapping of the records, and the consequent confusion when the diagram is rapidly changing in form, owing to variation of load, ignition, carburation, etc., an automatic switch is employed, which controls the recording mechanism so that it is disconnected from the record after one complete engine cycle. The indicator weighs only 3 pounds. It is a compact and convenient instrument for the production of diagrams from internal combustion engines, and is especially suitable for track tests and for aircraft engines in flight. Additional features are mentioned in List No. 153 issued by the Cambridge Instrument Company, Inc., 3512 Grand Central Terminal, New York, N. Y.

Oil Burner Controls

The Honeywell Heating Specialties Co., Wabash, Ind., have issued a catalog on their oil burner controls.

Optical Pyrometer

The Pyrometer Instrument Company, 74 Reade St., New York, N. Y., have issued a catalogue describing their new simplified optical pyrometer. They state "This new type of optical pyrometer has all the features of the highest type precision investments and in addition it excels all other makes as to compactness, ease of operation and weight. Pyro is entirely self-contained." A common dry cell flash light battery is used. This was made possible by developing a special lamp which requires but 60 milliamperes. The normal range of the instrument is 2000°F to 3200°F. Magnification of telescope is 4 times. Weight of the instrument is only 3 pounds.

Orifice Meters

Improved Orifice Methods is the title of Bulletin No. 159 recently published by The Foxboro Co., Inc., Foxboro, Mass.

Photo-Electric Cell

The Burt-Cell is the subject of Bulletin No. 271 issued by Dr. R. C. Burt, 327 South Michigan Ave., Pasadena, California.

Photometer

The description, manipulation and prices of the New Model Ives Tint Photometer are given in a recent bulletin of the Palo Co., 153 West 23 Street, New York, N. Y.

Pyrometers

Catalog L issued by the Wilson-Maeulin Company, 383 Concord Ave., New York, N. Y., is just off the press. It describes recording, indicating and automatic controlling pyrometers.

Pyrometer Protection Tubes

Louis C. Eitzen Co., 280 Broadway, New York, N. Y., have issued a new price sheet on pyrometer protection tubes. Standard sizes are also listed.

Radiation Pyrometer

The Pyrometer Instrument Company, 74 Reade Street, New York, N. Y., have revised their bulletin No. 20 on the Pyro Radiation Pyrometer. This bulletin is now available for distribution.

Recording Unit for Surface Condensers

Is the title of Bulletin 827 issued by the Esterline-Angus Co., Indianapolis, Ind. This instrument furnishes the answers to the following questions. What vacuum is maintained? Is cooling water leaking into the condenser? Is water coming over with steam from the boilers?

Stack Meter

Bulletin 262 of Charles Engelhard, Inc., 90 Chestnut St., Newark, N. J., explains the principles of combustion in boilers, together with fuel and furnace conditions. The operation and application of the Engelhard CO_2 recorder is described very fully by diagrams.

Stress Recorder

The Cambridge Instrument Company, Inc., 3512 Grand Central Terminal, New York, N. Y., have issued List No. 159 covering the Collins Stress Recorder, which is a light robust instrument for the measurement of stresses in bridges and other structures subjected to moving loads.

Tachometers

The Jones Tachometers is the title of a booklet issued by The Consolidated Instrument Company of America, Inc., 41 East 42 St., New York, N. Y. The various types which are used for a vast number of applications are listed.

Volume Control for Gas and Air Lift

The Foxboro Co., Inc., Foxboro, Mass. have recently issued Bulletin 158 which describes the Foxboro Volume Controller for use in the oil well field.

Buyers' Guide

Instruments and accessories used for measurement, inspection or control in the industries and sciences.

If you are unable to find what you require in the Buying Section of Instruments—Industrial and Scientific, fill in the form below and we will obtain full particulars for you without charge. Give complete information of requirements.

ALIDADES
Otto Fennel Sons

AMMETERS
Indicating
Hoyt Electrical Instrument Works
Rawson Electrical Instrument Company
Recording
Bristol Company

ANEMOMETERS
Colonial Supply Company
B. K. Elliott Company

BAROMETERS
Aneroid, Mercurial, Recording
Colonial Supply Company
B. K. Elliott Company

CARBON DIOXIDE METERS
Bacharach Industrial Instrument Co.

CARBON MONOXIDE METERS
Bacharach Industrial Instrument Co.

COMPASSES
Otto Fennel Sons

CONTROLS, AUTOMATIC
Float
American Radiator Company
Motor
American Radiator Company
Pressure & Vacuum
American Radiator Company
Bristol Company
Pyrometer
Bacharach Industrial Instrument Co.
Bristol Company
Wilson-Maeulin Company, Inc.
Refrigeration
American Radiator Company
Temperature
American Radiator Company
Automatic Electric Heater Company
Bacharach Industrial Instrument Co.
Bristol Company
Wilson-Maeulin Company, Inc.
Thermometer
Bristol Company
Wilson-Maeulin Company, Inc.
Thermostat
American Radiator Company
Automatic Electric Heater Company
Bristol Company
Unit Heater
American Radiator Company
Valve—Motor Operated
American Radiator Company
Bristol Company
Water Level
American Radiator Company
Bristol Company

COUNTERS
Revolution
Adde Company
Stroke
Adde Company

DEMAND METERS—see Meters

DRAFT GAUGES—see Gauges

ENGINE INDICATORS
Bacharach Industrial Instrument Co.

FLOW METERS—see Meters

FLUXMETERS
Rawson Electrical Instrument Co.

FREQUENCY METERS
Recording
Bristol Company

GAS ANALYTICAL METERS
Electric
Bacharach Industrial Instrument Co.
Hydrogen
Bacharach Industrial Instrument Co.
Portable
Bacharach Industrial Instrument Co.
Sulphur Dioxide
Bacharach Industrial Instrument Co.

GAUGES
Indicating
Draft
Bacharach Industrial Instrument Co.
Bristol Company
Water Level for Boilers
Bristol Company
Rain
B. K. Elliott Company
Recording
Distance
Bristol Company
Draft
Bacharach Industrial Instrument Co.
Bristol Company
Pressure & Vacuum
Bacharach Industrial Instrument Co.
Bristol Company
Colonial Supply Company
Water Level for Boilers
Bristol Company

IMPACT TESTING MACHINES
Alternating
Pittsburgh Instrument & Machine Co.

HARDNESS TESTERS
Pittsburgh Instrument & Machine Co.
Wilson-Maeulin Company, Inc.

HUMIDITY RECORDERS
Wet & Dry Bulb Thermometers
Bristol Company

HYGROMETERS
Colonial Supply Company

LEVELS
Engineer's, Wye, Precision
B. K. Elliott Company
Otto Fennel Sons
Pittsburgh Instrument & Machine Co.

MANOMETERS
Bacharach Industrial Instrument Co.

MEGOHMMETERS
Herman H. Sticht and Company

METERS
Demand
Gas
Bacharach Industrial Instrument Co.
Flow
Gas & Air
Bacharach Industrial Instrument Co.
Lineal Measuring
Adde Company
Pressure
Bacharach Industrial Instrument Co.

MICROAMMETERS
Rawson Electrical Instrument Company
Wilson-Maeulin Company, Inc.

MICROMETERS
Colonial Supply Company

MICROSCOPES
Brinell
Pittsburgh Instrument & Machine Co.
Metallographic
E. Leitz, Inc.
Petrographical
E. Leitz, Inc.

MILLIAMMETERS
Hoyt Electrical Instrument Works
Rawson Electrical Instrument Company
Wilson-Maeulin Company, Inc.

MILLIVOLTMETERS
Bristol Company
Hoyt Electrical Instrument Works
Rawson Electrical Instrument Company
Wilson-Maeulin Company, Inc.

MOTION RECORDERS
Mechanical
Bristol Company

OHM METERS
Rawson Electrical Instrument Company
Herman H. Sticht and Company

OPERATION RECORDERS
Electrical
Bristol Company

PLANIMETERS
Radial
Bristol Company

POSITION RECORDERS
Bacharach Industrial Instrument Co.

PRESSURE METERS—see Meters

PSYCHROMETER
Sling
Colonial Supply Company

PYROMETERS
Optical
Bacharach Industrial Instrument Co.
Pyrometer Instrument Company
Radiation
Indicating
Bacharach Industrial Instrument Co.
Colonial Supply Company
Pyrometer Instrument Company

BUYERS' INQUIRY FORM

INSTRUMENTS—*Industrial and Scientific*
1117 Wolfendale St.,
Pittsburgh, Pennsylvania.

GENTLEMEN:—

Please furnish information on the following:

_____

_____

_____

_____

_____

_____

_____

NAME_____

ADDRESS_____

COMPANY_____

POSITION_____

Recording
Bacharach Industrial Instrument Co.

Thermo-electric
Immersion
Bacharach Industrial Instrument Co.
Bristol Company
Pyrometer Instrument Company
Wilson-Maculin Company, Inc.
Indicating
Bacharach Industrial Instrument Co.
Bristol Company
Wilson-Maculin Company, Inc.
Recording
Bacharach Industrial Instrument Co.
Bristol Company
Wilson-Maculin Company, Inc.
Surface Contact
Bristol Company

SHEET METAL TESTERS
Pittsburgh Instrument & Machine Co.

SPECIAL ELECTRICAL INSTRUMENTS
Rawson Electrical Instrument Company

STEEL TAPES
Colonial Supply Company
Otto Fennel Sons
Pittsburgh Instrument & Machine Co.

TACHOMETERS
Bristol Company
Colonial Supply Company
Pyrometer Instrument Company
Herman H. Sticht and Company

THEODOLITES
Otto Fennel Sons
Pittsburgh Instrument & Machine Co.

THERMO-JUNCTIONS (Electric)
Rawson Electrical Instrument Company

THERMOMETERS
Gas Filled
Indicating and Recording
Bristol Company
Colonial Supply Company
Mercurial
B. K. Elliott Company
Resistance
Indicating
Wilson-Maculin Company, Inc.
Recording
Wilson-Maculin Company, Inc.

THERMOSTATS
American Radiator Company
Automatic Electric Heater Company
Bristol Company

TRANSITS
Engineer's, Surveyors, Mine
B. K. Elliott Company
Otto Fennel Sons
Pittsburgh Instrument & Machine Co.

VOLTMETERS
Indicating
Hoyt Electrical Instrument Works
Rawson Electrical Instrument Company
Recording
Bristol Company

WATTMETERS
Indicating
Rawson Electrical Instrument Company
Recording
Bristol Company

Advertisers Index

A Page

Adde & Company, Portland, Maine 13
American Radiator Co., 816-820 S. Michigan Ave., Chicago, Ill. 1
Automatic Electric Heater, 1505 Race Street, Philadelphia, Pa. 11

B

Bacharach Industrial Instrument Co., 7008 Bennett St., Pittsburgh, Pa. 4
Bristol Co., The, Waterbury, Conn. ..... **Inside Back Cover**

C

Colonial Supply Co., 217 Water Street, Pittsburgh, Pa. 3

E

Elliott Co., B. K., 127 Sixth Street, Pittsburgh, Pa. ..... **Inside Front Cover**

F

Fennel Sons, Otto, Kassel, 85, Germany 13

H

Hoyt Electrical Instrument Works, 857 Boylston St., Boston, Mass. 13

L

Leitz, Inc., E., 60 East Tenth Street, New York, N. Y. 11

P

Pittsburgh Instrument & Mach. Co., 1026 Reedsdale St., Pittsburgh, Pa. 10
Pittsburgh Piping & Equipment Co., 43rd St. and A.V.R.R., Pittsburgh, Pa. **Back Cover**
Pyrometer Instrument Co., 74A Reade St., New York, N. Y. 5

R

Rawson Electrical Instrument Co., 90-92 Windsor St., Cambridge, Mass. 7

S

Sticht & Co., Herman H., 21 Park Row, New York, N. Y. 9

W

Wilson-Mauelen Co., Inc., 381 Concord Ave., New York, N. Y. 16

THE fact that great oaks grow from little acorns gives us hope as we go to press with the first issue of INSTRUMENTS.

You may judge for yourself whether we have succeeded in this issue—we know we have allowed ample room for improvement.

OUR appearance is in agreement with the manner in which the men behind this periodical have always done things—creeping activities occur before walking exercises take place. It is our knowledge that each succeeding issue will be better than the one before. Our readers will therefore always have something to look forward to.

INSTRUMENTS PUBLISHING CO.

CUT OUT THESE CARDS AND PLACE IN YOUR FILE

CUT OUT THESE CARDS AND PLACE IN YOUR FILE

Below are standard file cards, which the editor believes will be a valuable asset to you personally. These cards will be bound in each issue of Instruments and will cover the original articles contained in that issue. The color of the card and ink to be used is shown here. This will facilitate distinguishing the INSTRUMENTS FILE CARDS from others with which they might be consolidated.

The editor suggests that these cards be carefully cut out immediately on receipt of INSTRUMENTS and filed in your desk or in a file box on top of your desk. You will then have within easy reach an index of instrument information of incalculable value.

The card is arranged with a space for classification subject or number at the top. Suggestions as to classifications for the cards below are:

MICROSCOPY
MAGNETIC TESTING

THE USE OF THE MICROSCOPE IN INDUSTRY.

ROBERT G. GUTHRIE. INSTRUMENTS, Vol. 1, No. 1, pp. 5-27, 49 figs.

The three types of microscopes most commonly used in industrial work, biological, petrographical and metallurgical, are briefly discussed. The article then considers the results obtained with the latter of these as applied to the study of steel. Micrographs of various samples with different magnifications are shown. The effect of heat treatment and furnace atmosphere are illustrated. Abnormal steels and special steels are also shown in micrographs.

A RÉSUMÉ OF THE MAGNETIC METHODS EMPLOYED IN STUDYING THE MECHANICAL PROPERTIES OF MATTER.

DR. S. R. WILLIAMS. INSTRUMENTS, Vol. 1, No. 1, Jan. 1928, pp. 29-38 9 figs.

Data obtained from experiments by the author and other investigators indicates that for every physical and chemical change in materials there is a corresponding variation in the magnetic properties.

Graphs are offered showing the relationship between change in length and magnetic stress on bars of manganese alloy, cobalt, steel and nickel. It is found that especially in steel a close relationship exists between this change in length and the hardness of the samples.

A laboratory device developed by the author for testing hardness of steel balls is described. This instrument depends on the fact that when a steel ball is placed between the poles of a horseshoe magnet the field is reduced an amount, depending on the hardness of the balls. A magnetometer is used to measure the intensity of the field. Comparative tests on samples were made with this instrument, a Rockwell hardness tester and by the rebound test. A plot of the results obtained by the various tests shows the magnetic method to compare favorably with two standard methods, especially the Rockwell method.

The most practical use of magnetic tests at present is to locate flaws and mechanical imperfections. Occasional inhomogeneities cause a change in the magnetic permeability of an otherwise homogeneous sample. Most electro-magnetic devices for indicating flaws take advantage of this fact. Some of the devices developed to date are described and discussed.

In conclusion, the author points out the necessity of extensive research to establish definite relationships between magnetic and mechanical properties.

TIGH

BOU

SAND TESTS—WHAT DO THEY MEAN?

A. A. GRUBB. INSTRUMENTS, Vol. 1, No. 1, Jan. 1928, pp. 39-40 2 figs.

The methods of testing molding sand and the relation of such tests to working properties of sand are discussed. Particle size of grain and clay is emphasized as the important factor in determining permeability and bond strength. Transverse, tensile and compressive tests for bond strength are compared and the meaning of the results is discussed.

HTLY

UND

any diffi-
ting, sev-
ipally the

he use of
f portable
it for he-
ium value
and that
hen meas-
increasing
t is given

COMPLETE GAS ANALYSIS BY THE SIMULTANEOUS OXYDATION OF METHANE, CARBON MONOXIDE AND HYDROGEN.

HOFRAT PROFESSOR VON JUEPTNER. INSTRUMENTS, Vol. 1, No. 1, Jan. 1928, pp. 55-57.

Complete analyses of gases, containing oxygen, nitrogen, hydrogen, carbon monoxide, carbon dioxide, methane and heavy hydrocarbons involve many difficulties. The method, recommended is that of Dr. Kress, which carries out the simultaneous combustion of hydrogen, carbon monoxide and methane in a water cooled explosion pipette after the carbon dioxide, heavy hydrocarbons and oxygen have been removed in absorption pipettes. An illustration gives the necessary calculations.

TIGH

BOU

SAND TESTS—WHAT DO THEY MEAN?

A. A. GRUBB. INSTRUMENTS, Vol. 1, No. 1, Jan. 1928, pp. 39-40 2 figs.

The methods of testing molding sand and the relation of such tests to working properties of sand are discussed. Particle size of grain and clay is emphasized as the important factor in determining permeability and bond strength. Transverse, tensile and compressive tests for bond strength are compared and the meaning of the results is discussed.

HTLY

UND

COMPLETE GAS ANALYSIS BY THE SIMULTANEOUS OXYDATION OF METHANE, CARBON MONOXIDE AND HYDROGEN.

HOFRAT PROFESSOR VON JUEPTNER. INSTRUMENTS, Vol. 1, No. 1, Jan. 1928, pp. 55-57.

Complete analyses of gases, containing oxygen, nitrogen, hydrogen, carbon monoxide, carbon dioxide, methane and heavy hydrocarbons involve many difficulties. The method, recommended is that of Dr. Kress, which carries out the simultaneous combustion of hydrogen, carbon monoxide and methane in a water cooled explosion pipette after the carbon dioxide, heavy hydrocarbons and oxygen have been removed in absorption pipettes. An illustration gives the necessary calculations.

CUT OUT THESE CARDS AND PLACE IN YOUR FILE

CUT OUT THESE CARDS AND PLACE IN YOUR FILE

SAND TESTS—WHAT DO THEY MEAN?

A. A. GRUBB. INSTRUMENTS, Vol. 1, No. 1, Jan. 1928, pp. 39-40 2 figs.

The methods of testing molding sand and the relation of such tests to working properties of sand are discussed. Particle size of grain and clay is emphasized as the important factor in determining permeability and bond strength. Transverse, tensile and compressive tests for bond strength are compared and the meaning of the results is discussed.

A PORTABLE PHOTOMETER FOR MEASURING COLORED LIGHT.

LOUIS E. BARBROW. INSTRUMENTS, Vol. 1, No. 1, pp. 51-54 2 figs.

In photometry, the presence of color difference is very disconcerting since it leads to many difficulties in making measurements. Where color difference cannot be eradicated in laboratory testing, several methods have been introduced to overcome the resulting difficulties. These are principally the Flicker Photometer, the use of colored filters, and the Cascade method.

For a portable photometer, however, none of these methods is quite suitable, although the use of filters probably comes closest to being so. The Macbeth Illuminometer is a convenient form of portable photometer which is quite extensively used in practice. In attempting to use this instrument for heterochromatic measurements by inserting colored filters, however, it was found that the maximum value that could be obtained with the working standard originally used in the instrument was too low and that this condition could not very well be remedied by increasing the intensity of the standard as then measurements of low intensities could not be made accurately. This condition was remedied by increasing both the light intensity and the length of the photometer tube. The design of the instrument is given in the article.

COMPLETE GAS ANALYSIS BY THE SIMULTANEOUS OXYDATION OF METHANE, CARBON MONOXIDE AND HYDROGEN.

HOFRAT PROFESSOR VON JUEPTNER. INSTRUMENTS, Vol. 1, No. 1, Jan. 1928, pp. 55-57.

Complete analyses of gases, containing oxygen, nitrogen, hydrogen, carbon monoxide, carbon dioxide, methane and heavy hydrocarbons involve many difficulties. The method, recommended is that of Dr. Kreas, which carries out the simultaneous combustion of hydrogen, carbon monoxide and methane in a water cooled explosion pipette after the carbon dioxide, heavy hydrocarbons and oxygen have been removed in absorption pipettes. An illustration gives the necessary calculations.

Strip chart model recording pressure gauge

Automatic Pressure Controller

BRISTOL'S

for

Recording and Controlling Pressures

SOME thirty-odd years ago Bristol's Recording Pressure Gauge equipment was installed at the Manayunk Pumping Station, Philadelphia, Pennsylvania. Just recently newer Bristol's equipment replaced the older models which has given more than 24,000 hours continuous service *without requiring one cent for repairs*—typical Bristol's economy.

Likewise the Bristol's Automatic Pressure Controller is designed and built according to the same principles which make such remarkable service possible.

A survey of instrument needs in your plant will be made by highly trained Service Engineers, without obligating you in any way. Their experience in handling the special requirements of hundreds of installations assures equipment that will exactly suit the particular needs of your plant.

The Most Complete Line

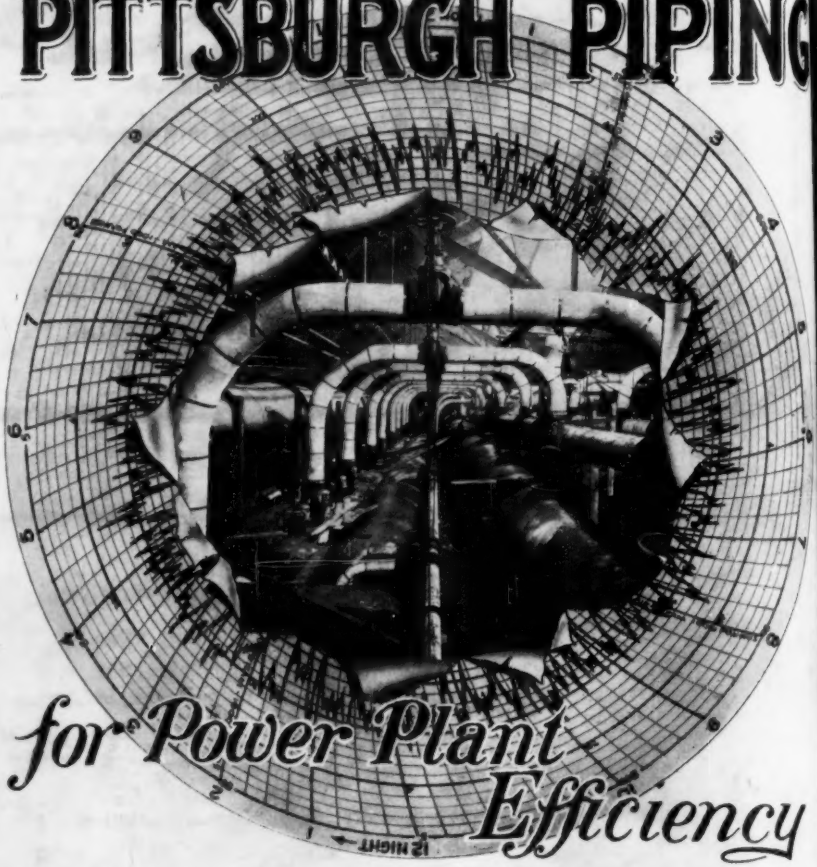
of Recording and Control equipment including: Pressure, Pressure Control; Liquid Level; Temperature, Temperature Control; Electricity, Speed, Motion, Humidity, etc. Write for catalogs.

The Bristol Company

Waterbury, Connecticut

Boston Philadelphia Birmingham Chicago Denver
New York Pittsburgh Detroit St. Louis San Francisco

PITTSBURGH PIPING



for Power Plant Efficiency

Industrial Instruments are important in the Power Plant, but no less important is your Power Plant Piping.

We are fully equipped to not only furnish fabricated materials but to install complete piping systems for Electric Power Stations, Blast Furnaces, Steel Mills, Coke Works and Industrial plants of every description.

Let us solve your piping problems.

PITTSBURGH PIPING & EQUIPMENT CO.

43rd Street and A.V.R.R., Pittsburgh, Pa.

Specialists in Welded Wrought Steel Headers, Flanged Iron and Steel Fittings, Pipe Bends and Fabricated Piping for Power Plants

NEW YORK, 220 *Broadway*
CLEVELAND, *Ulmer Building*
CHICAGO, *Peoples Gas Building*
SAN FRANCISCO, *Call Building*

INDIANAPOLIS, *Trac. Term. Bldg.*
DETROIT, *Gen. Motors Bldg.*
HOUGHTON, MICH., *Dee Bldg.*
BOSTON, *10 High Street*

DALLAS, TEXAS, *Am. Ex. Bk. Bldg.*